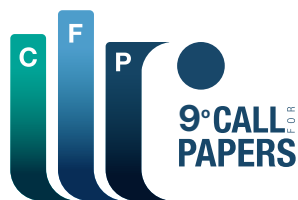


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David Santiago Caraballo Candela

*EVALUACIÓN DE IMPACTO DEL
TLC COLOMBIA - COREA: UNA
APROXIMACIÓN EMPÍRICA*

Aso
Ban
Caria

90 Años
Acercando la
Banca a los
Colombianos

IMPACT ASSESSMENT OF THE COLOMBIA-KOREA FTA: AN EMPIRICAL APPROACH*

David Santiago Caraballo Candela[†]

Abstract

This paper examines the impact of the Colombia-Korea Free Trade Agreement (FTA) on trade flows following its entry to force, sanctioned by the Colombian government in 2016. Employing a structural gravity model of trade and synthetic control methods, it estimates trade creation and trade diversion effects at both aggregate and sectoral levels. Results suggest that, while the FTA did not significantly impact overall trade flows, Colombia experienced a notable trade creation effect, with a 54% increase in exports, particularly in agricultural products and heavy metals. In contrast, Korea saw a 28% decline in its trade volume, primarily due to reduced sales of automotive, and industrial and electronic machinery. Evidence also points to null trade diversion effects among the FTA members, which is consistent with expectations given the low economic interdependence between the two countries, as trade flows with their usual regional partners have been sustained.

Keywords: trade flow, FTA, gravity model, synthetic counterfactual.

JEL Codes: F10, F14, F15.

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[†]Universidad de los Andes, Colombia. E-mail: ds.caraballo@uniandes.edu.co



EVALUACIÓN DE IMPACTO DEL TLC COLOMBIA- COREA: UNA APROXIMACIÓN EMPÍRICA*

David Santiago Caraballo Candela[†]

Resumen

Este artículo examina el impacto del Tratado de Libre Comercio (TLC) entre Colombia y Corea del Sur sobre los flujos comerciales luego de su entrada en vigor, sancionado por el Gobierno colombiano en 2016. Empleando un modelo gravitacional estructural del comercio y métodos de control sintético, se estiman los efectos de creación y desviación de comercio tanto a nivel agregado como sectorial. Los resultados sugieren que, si bien el TLC no afectó significativamente los flujos comerciales totales, Colombia experimentó un notable efecto de creación de comercio, con un aumento del 54% en las exportaciones, particularmente en productos agrícolas y metales pesados. En contraste, Corea del Sur registró una disminución del 28% en su volumen comercial, debido principalmente a la reducción en las ventas de maquinaria automotriz, industrial y electrónica. La evidencia también sugiere efectos nulos de desviación de comercio entre los miembros del TLC, lo cual es consistente con las expectativas, dado el bajo nivel de interdependencia económica entre ambos países, ya que se han mantenido los flujos comerciales con sus socios regionales habituales.

Palabras clave: flujo comercial, TLC, modelo de gravedad, control sintético.

Códigos JEL: F10, F14, F15.

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[†]Universidad de los Andes, Colombia. Correo electrónico: ds.caraballo@uniandes.edu.co

1 Introduction

Free Trade Agreements (FTAs) exercise a pivotal role in the international trade landscape by molding market access, production methods, and ultimately, trade flows. The current trend in commercial policies is notably marked by the proliferation of FTAs (Yamanouchi, 2019); since 2000, over 250 regional economic integrations have been officially reported to enter into force, varying in their target, extension, and scope.¹ Broadly speaking, all FTAs aim to enhance product exchange and improve welfare (Aykaç and Demiroglu, 2021).

Getting the utmost benefit from the FTAs is crucial for developing countries as they strive to boost their competitiveness and expand their participation in the world economy. Such is the context of Colombia's FTAs. Initiated with the so-called "economic opening" in the early 1990s, fostered by then-President César Gaviria, the country has strategically engaged in signing trade agreements to propel its external market integration.

The Colombia-Korea FTA stands out as a bold initiative for several reasons. First, it was the first bilateral trade agreement to be signed (in 2013) with an East Asian country that was neither the region's nor the continent's main trading partner. Second, it offered exceptionally generous concessions for immediate tariff eliminations (82% of the export portfolio). Third, it is one of the most recent economic integrations to come into effect for both countries (in 2016). Fourth, it is a trade agreement with a multidimensional distant partner in terms of geography, culture, and language, among others.

This paper assesses the impact of the Colombia-Korea FTA by focusing on its trade creation and trade diversion effects over the period 2016-2022.² The analysis is based on two *ad-hoc* hypotheses: $\mathbb{H}_1$ Heterogeneous production structures lead to specialization, and thus, to sector-differentiated trade creation, and $\mathbb{H}_2$ Existing commercial networks lead to null trade diversion due to established trade flows and complementary economies. This contrasts with usual customs union effects, which mostly divert trade (Lipsey, 1957), as countries with low economic complementarity do not tend to redirect imports.

The effects of FTAs on trade flows have been extensively analyzed. Still, the existing literature remains ambiguous about whether joining an FTA results in actual gains. The European Economic Community (EEC) had statistically significant effects on increasing trade by 60% among members (Abrams, 1973; Aitken, 1973; Brada and Mendez, 1985). Yet, Bergstrand (1985) challenges these findings by concluding that no perceivable impacts were present. Frankel et al. (1995) also note the absence of significant trade increases from 1970-1980, but establishes that *Mercado Común del Sur* (MERCOSUR) also experienced positive impacts after its inception (1991), a success not mirrored by *Comunidad Andina* (CAN) despite targeting similar economic objectives in -nearly- the same countries.

¹See the [Regional Trade Agreements Tracker](#) (last accessed 10th of February, 2024).

²Trade creation is the increase in trade among members of an integration bloc as a result of lower goods prices after tariffs and non-tariff barriers have been reduced or eliminated. Trade diversion refers to the shift of imports from a more efficient exporter outside the bloc to a less efficient one within the bloc as a result of higher tariff and non-tariff protection measures applied to non-bloc trading partners.



Yet, attempts have been made to give the matter a final thrust. [Baier and Bergstrand \(2007\)](#) showed that a conventional integration agreement doubles two members' bilateral trade after a decade; a result supported by [Anderson and Yotov \(2015\)](#) who used a similar identification strategy. Still, the majority of this literature comes with a caveat; the trade benefits derived from FTAs are not uniformly distributed across sectors and countries.³

For instance, [Grant and Lambert \(2008\)](#) showed that FTAs increase agricultural trade flows value by, on average, 72% (and up to 149% after twelve years), compared with 27% gains for non-agricultural trade. Moreover, [Larch et al. \(2016\)](#) indicated that FTAs treatment effects are weaker for more distant country-pairs and for pairs with otherwise high levels of *ex-ante* trade frictions; like FTAs already placed. This phenomenon is particularly evident in the case of FTAs among economies with heterogeneous technology and factor endowments ([Bergstrand, 1990](#); [Hong and Oh, 2016](#)).

There have been very few econometric analyses addressing the Colombia-Korea FTA potential results on aggregate and/or sectoral trade flows (see [Muñoz, 2015](#)). Instead, they have focused on qualitatively characterizing and predicting the commercial opportunities that the arrival would create in some specific regions (see [Armero et al., 2016](#); [Serna and Wallis, 2012](#)). This trend has continued following its entry to force to date. Almost eight years have elapsed, and yet, there is little awareness of its trade impacts.

Only a handful of publications have undertaken the task of reviewing the components of the agreement and its observed “preliminary” results. [Ariza \(2020\)](#) and [Murillo \(2019\)](#) recognize, at first glance, apparent trade gains that the FTA has had on agriculture and manufacturing through major development of the Colombian industry owe to investment, others have highlighted major challenges the FTA has faced in the first operative years like the regulatory differences and product quality ([Ebrath, 2018](#)), or have conducted a cost-benefit analysis which dims its prospects ([Herrera et al., 2019](#)). Hence, a more rigorous *ex-post* empirical assessment of the *de-facto* outcomes to date is lacking.

This paper intends to fill this gap in the relevant literature and contribute along two strands. On the one strand, it sheds light on the FTA's performance by exploiting the tariff concession levels. As of today, both parties have already liberalized more than 90% of their export portfolio; which means that most of the mid-term impacts ought to have manifested by now. Therefore, it provides an opportunity to quantify them, being the first to focus on trade creation and trade diversion effects.

On the other strand, it employs a two-stage identification strategy for a more robust inference. First, a gravity model of trade following [Anderson and van Wincoop \(2004\)](#)'s “gold standard” workhorse for trade policy analysis is estimated, and then its results are adopted as input for building synthetic counterfactuals, a method developed by [Abadie and Gardeazabal \(2003\)](#), of the treatment effects. Detailed interpretations of their results are provided for both stages to evaluate the consistency between models.

³[Ghosh and Yamarik \(2004\)](#) address the “fragility” of estimated FTA treatment effects, finding evidence that most economic integration trade gains are sensitive and context-dependent.

To study the effect of the FTA on trade flows, this paper examines two approaches: i) the symmetric approach, which estimates the average treatment effect, and ii) the asymmetric approach, which accounts for directional variations in effects. This exercise is used to compute both the trade creation and trade diversion effects at the aggregate level. To improve consistency, trade creation effects are also evaluated at the sectoral level. So far, few research has used this empirical strategy ([Adarov, 2022](#); [Hannan, 2016](#)), and its application to the Colombia-Korea FTA is entirely novel. This establishes a framework for studying economic integrations with diverse member baselines.

The strategy primarily relies on two annual panel datasets: Gravity, used for assessing aggregate-level effects, and BACI, used for a more detailed sectoral analysis, both sourced from the *Centre d'Études Prospectives et d'Informations Internationales* (CEPII). Additional data/indicators frame and aid in reviewing the results. The analysis sample exploits the 2005-2022 period to verify the identification assumptions. It also targets a subset of Colombia's partners exceeding \$100 million total trade volume, i.e., exports plus imports, over the last decade (103 countries).

Several findings stand out from the gravity model and the synthetic counterfactual estimates. The symmetric approach's aggregate results suggest an absence of economically and statistically significant trade creation effects attributable to the FTA. Nonetheless, under an asymmetric approach, Colombia exhibited a trade flow increase of between 54% to 177%, but Korea decreased theirs of between 28% to 48%. Synthetic counterfactual estimates back up these results since, for all post-treatment periods, Colombia shows a net positive effect on trade flows, while Korea displays a net negative one.

Overall, most FTA-related gains for Colombia come from exports of agricultural goods, including coffee, tea(s), spices, and fruits, while Korea's losses are due to a decline in car and automotive sales. However, global political and economic factors, such as exchange rate fluctuations and regional tariff liberalizations, may be influencing the sectoral results, thus limiting their causal interpretation. Both countries also experience trade creation effects in non-FTA-related sectors. Colombia capitalizes on its fuel, mineral, and metal resources to export to Korea, while the latter increases its exports of plastics, pharmaceuticals, and organic chemicals to Colombia, although it has reduced its shipments of industrial equipment and electronic machinery.

Canonical gravity model specifications reveal that geography imposes a trade barrier, while sharing a terrestrial border and colonial heritage eases it, consistent with the literature. In contrast, religious and language differences are not significant, contradicting the presumption of augmented transaction costs.

The inception of the FTA was also associated with null trade diversion effects in its strict sense. There were no significant import shifts from regions with which Colombia and Korea normally trade (e.g., Latin America and the Caribbean (*LAC*) and East and Southeast Asia (*ESEA*)). Again, synthetic counterfactuals provide supportive evidence. Yet, once relaxing the sense, only Korean exports to *LAC* seem to slightly diminish.



Indeed, two mechanisms are proposed: i) regarding trade creation effects, the disparity in market saturation levels limits export growth potential. Colombia leverages its flexible industrial capacity to meet growing demand, while Korean industries are likely constrained by diminishing returns and higher relative prices; ii) regarding trade diversion effects, well-established trade relationships and efficient logistics networks within regional trade hubs reduce incentives to utilize the FTA, especially when lower-cost imports are available.

Notably, when varying the sample size in the time frame and country count terms, trade creation and trade diversion effects hold directionality and statistical significance. Even after removing the traditional export trade flow values from both parties, the majority of the effects hold. Then, spatial and temporal placebo tests are conducted on the synthetic counterfactual estimates to show that they are not a result of random chance but rather correspond to the causal effect of the trade policy.

This paper is organized as follows. Section 2 briefly reviews key features of Colombia and Korea's trade profiles as well as the FTA-specifics. Section 3 describes the empirical strategy for testing the hypotheses, along with the identification assumptions and threats to the methodology. Section 4 outlines and discusses the estimation results, while Section 5 checks their robustness. Section 6 presents public policy implications derived from the empirical exercise. Finally, Section 7 conveys the concluding remarks.

2 The Colombia-Korea FTA: Stylized Facts

While political relations between Colombia and Korea have been in good health for over six decades because of Colombia's role in the Korean War, economic ties have recently seen a notable surge despite their wide geographical distance, focusing primarily on socio-cultural issues to reduce the gap of mutual unfamiliarity and regional differences.

There have been significant milestones in the trade sphere, especially from the 2010s onwards, which have enhanced goods exchange and foreign investment. For instance, the *Acuerdo de Promoción y Protección de Inversión* (APPRI) signed in 2010, established a legal framework that set more favorable and reciprocal conditions for capital outlays in both countries. The APPRI enabled the highest levels of Korean investment in Colombia, with \$43.7 million (2012) and \$42.9 million recorded (2015) (MinCIT, 2024).

The discussion of a bilateral FTA began in July 2008 at Colombia's request and gained momentum when both parties recognized its need during the summit meeting held later that year. Negotiations started in December 2009 and culminated in a joint declaration in June 2012. The agreement faced ratification by Korea's (Colombia's) Congress in April (December) and in December 2014. It finally came into effect in July 2016.

For Colombia, its importance yields in the intention to diversify its markets towards East Asia, including India, Japan, and China, boosting industries with Korean investment and technology transfers. It also facilitates cooperation, strengthens ties between LAC and ESEA, and positions Colombia as a crucial partner in the region.

For Korea, the FTA marked its third with a South American country. The first, with Chile in 2003, had positive impacts on bilateral trade flows, leading to a major increase in the value and variety of Chilean exports (Cáceres et al., 2022), and primarily enhancing the intensive margin of trade (Cáceres et al., 2023). The second, enacted with Peru in 2011, strengthened the complementarities between both economies, creating opportunities for development, expansion, and integration into Asian markets (Canahuire, 2016).⁴

2.1 Country Profiles

Since the late 20th century, both countries have undergone major transformations that have shaped their modern history. During the 90s, the Colombian government promoted trade liberalization and privatization policies, aiming to modernize the economy to a more globalized one. Nonetheless, the country also faced instability and violent periods related to internal armed conflicts, which undermined the investment climate and its welfare.

Despite this, Colombia managed to keep positive growth rates for much of the 2000s up to the early 2010s, driven by the boom in commodities (e.g., raw oil, natural gas, and coal), tourism, and security policies like *Seguridad Democrática* decreed by then-President Álvaro Uribe. Figures A1a and A1b support it, with a notable growth in the mineral and services sectors, but with a decline in agriculture, chemicals, and textiles until 2014.

The signing of the peace agreement in 2016 with the *Fuerzas Armadas Revolucionarias de Colombia* (FARC) rebel group opened new prospects for economic development after more than 60 years of strife, particularly in the distressed rural areas. Still, the country needs to keep diversifying its economy beyond energy sectors, improving infrastructure, reducing poverty and hunger, and addressing the recent climate change effects.

Korea, on the other hand, established itself as the third most advanced and diversified economy in Asia, beginning its “decisive” shift away from minerals and heavy metals. The Asian financial crisis of 1997-1998, however, was a turning point, forcing then-President Kim Dae-jung to restructure its industrial conglomerates (*chaebols*), reform the financial sector regulations, and guarantee free and transparent competition.

The country’s strategy for recovery in the following years was to invest in education and research, promoting innovation and cutting-edge technologies. As a result, it emerged as a world leader in sectors such as semiconductors, automotive, and biotechnology. Figures A1c and A1d provide evidence of it, they show a major developments in the manufacturing industry of vehicles and electronic machinery. Yet, the country keeps struggling with rapid population aging, exports dependency, and border tensions in the Korean Peninsula.

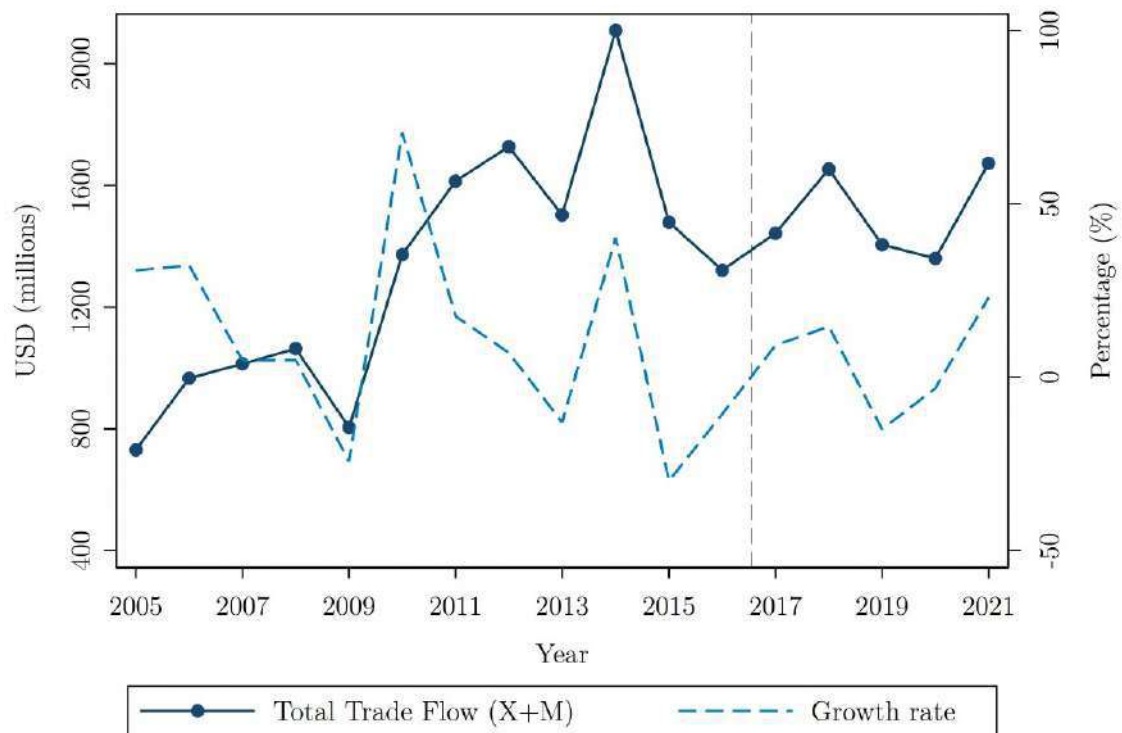
Table B3 captures Colombia’s and Korea’s macroeconomic indicators. Despite similar population sizes and foreign investment inflows, Korea’s smaller landmass supports an economy nearly five times larger in both total and per capita terms. Export and import volumes surpass Colombia’s by twelve and nine times, respectively. The external sector comprises over 84% of Korea’s GDP, compared to Colombia’s 39%.

⁴Tables B1 and B2 show the active economic integrations of Colombia and Korea to date, respectively.

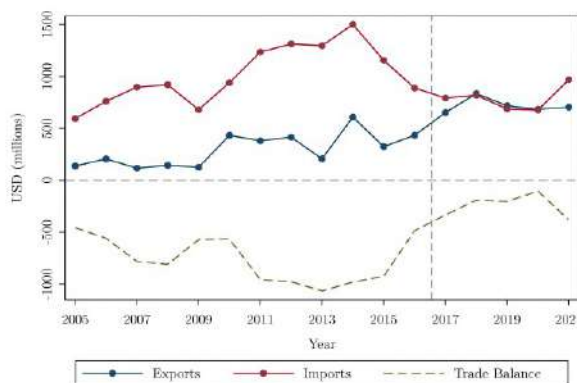


Figure 1: Trade Flows between Colombia and Korea

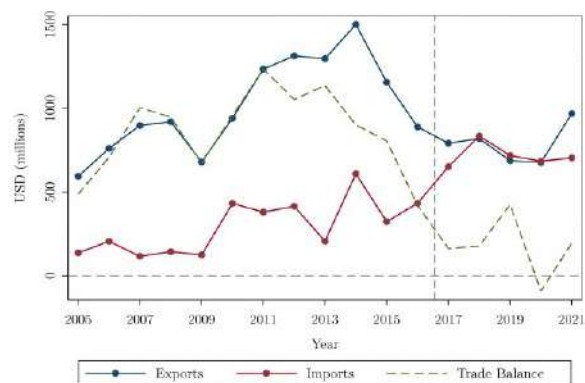
(a) Colombia and Korea Aggregate Exports



(b) Colombian Trade Flows to Korea



(c) Korean Trade Flows to Colombia



Notes: Panel (a) has two vertical axes. The left vertical axis plots the aggregate trade flows -blue solid line-, measured as the sum of Colombian exports and imports between 2005-2022. The right vertical axis plots the growth rate -sky blue dashed line- of the aggregate trade flows. Panels (b) and (c) are the disaggregation by country of Panel (a) including the trade balance -green dashed line-. A time threshold is set to mid-2016; the date the Colombia-Korea FTA came into effect. Prepared by the author using data from [UN Comtrade](#).

Figure 1 further explores the bilateral trade relations between Colombia and Korea. A prominent positive trend is evident from 2009-2014 with a peak trade volume of roughly \$2 billion. Figures 1b and 1c detail them at the individual level. Colombia's trade dynamic with Korea shows a sustained increase in both exports and imports, yet consistently runs a negative trade balance. After 2016, despite the trade and security policies deployment, Korea's exports to Colombia have diminished, resulting in a deficit by 2020.

Figure A2 identifies the remaining world trade partners and destinations (origins) of exported (imported) goods, as well as their volumes. Colombia's exports are concentrated, with the United States (US) as the principal recipient, alongside Brazil, China, and some EEC members. Its imports also feature China, Mexico, and the US, suggesting a "closed" trade network where few countries dominate the relationships. In turn, Korea's exports are diverse at both local and continental levels, with the US, China, Japan, among others, as major trade partners. The import pattern is quite identical, even adding more countries, highlighting its role as a member of complex supply chains.

This brings to mind $\mathbb{H}_2$, where both countries have incentives to continue importing while also developing industries where they historically have not excelled. Occasionally, a country may shift trade to others despite its natural resistance to change, even though tariff liberalization aims to encourage such shifts. Low economic interdependence country-pairs often lack trade diversion effects, as they typically already have tariff agreements with most competitors of the counterpart's products (Vallejo, 2004).

2.1.1 Revealed Comparative Advantage (RCA) Index

Based on Ricardian theory, the metric is mainly employed to provide general indications and a first approximation of a country's competitive export strengths at multiple analysis levels (e.g., product). Although difficult to check in reality, the RCA Index can be easily "revealed" using trade data. Balassa (1965) showed that patterns of trade among countries are governed by their relative differences in productivity as: $RCA_i^k = \frac{X_i^k / \sum_{l \neq k \in K} X_i^l}{X_W^k / \sum_{l \neq k \in K} X_W^l}$

where K is the set of all sectors, X_i^k is country i 's exports to sector k , X_W^k is the world's exports of sector k , while $\sum_{l \neq k \in K} X_i^l$ is country i 's total exports and $\sum_{l \neq k \in K} X_W^l$ is the world's total exports, both of all sector l different from k that belong to K .

An $RCA_i^k > 1$ suggests country i to be a competitive exporter of sector k products relative to a country $-i$ exporting at or below the world's average. The higher the value of the Index, the higher its comparative advantage. An $RCA_i^k = 1$ means the country's participation in that sector's market is on par with the world's average, neither advantageous nor disadvantageous, and an $RCA_i^k < 1$ imply a comparative disadvantage, with the country participating in the sector market below the world's average.

Table 1 shows the calculated RCA Index of Colombia and Korea of 16 Sector-Groups in 2011, 2016, and 2021, using the 2-digit Harmonized System (HS2) product classification. Key Sector-Groups for Colombia have shown ample growth in (1) Animal, increasing by 232%, (2) Vegetable products by 52%, suggesting enhanced efficiency due to improved agricultural practices. (4) Minerals increase (+93%) because of coal, ferronickel, emeralds, gold, and silver mining. (7) Plastic/Rubber rose from 0.72 to 0.97 (+35%), while (12) Stone/Glass grew from 1.32 to 1.94 (+47%). (5) Fuels industry remains robust with an RCA of 3.74 in 2021, despite a fall from 4.97 in 2016. However, (8) Hides/Skins, (9) Wood, (13) Metals, and (15) Transportation saw a net decline between 2011-2021.



Table 1: Colombia and Korea RCA Index by Sector-Group

Sector- Group	HS2	Description	Colombia				Korea			
			2011	2016	2021	$\bar{\Delta}$	2011	2016	2021	$\bar{\Delta}$
1	01-05	Animal	0.22	0.31	0.73	↑	0.17	0.14	0.09	↓
2	06-15	Vegetable	3.23	4.46	4.90	↑	0.05	0.05	0.04	↘
3	16-24	Foodstuffs	1.14	1.01	1.16	↗	0.19	0.26	0.34	↑
4	25-26	Minerals	0.14	0.21	0.27	↑	0.10	0.08	0.07	↓
5	27	Fuels	3.30	4.97	3.74	↗	0.53	0.54	0.47	↘
6	28-38	Chemicals	0.44	0.62	0.55	↗	0.73	0.79	0.95	↑
7	39-40	Plastic/Rubber	0.72	0.82	0.97	↑	1.61	1.58	1.57	↓
8	41-43	Hides/Skins	0.72	0.74	0.53	↘	0.39	0.38	0.31	↓
9	44-49	Wood	0.66	0.60	0.59	↓	0.29	0.29	0.23	↘
10	50-63	Textiles/Clothing	0.56	0.50	0.60	↗	0.67	0.56	0.44	↓
11	64-67	Footwear	0.14	0.12	0.15	↗	0.11	0.10	0.08	↓
12	68-71	Stone/Glass	1.32	1.80	1.94	↑	0.37	0.28	0.33	↘
13	72-83	Metals	0.44	0.44	0.27	↘	1.27	1.22	1.05	↓
14	84-85	E-Machinery	0.08	0.08	0.08	→	1.66	1.66	1.83	↗
15	86-89	Transportation	0.37	0.14	0.10	↓	1.55	1.28	1.27	↓
16	90-99	Miscellaneous	0.31	0.27	0.31	→	1.02	0.81	0.61	↓

Notes: $\bar{\Delta}$ mimics the raw average *RCA* variation between 2011-2021. This period is selected to account for the *RCA* values before, during, and after the inception of the FTA by a 5-year time frame. Arrow conventions are: ↑, strictly growing; ↓, strictly decreasing; ↗, net positive growth; ↘, net negative decrease, and →, for variation without change. Prepared by the author based on the 2-digit Harmonized System (HS2) grouping and [UN Comtrade](#) data.

On the other hand, Korea has experienced gains in (3) Foodstuffs, rising from 0.19 to 0.34 (+79%). As for (7) Chemicals and (14) E-Machinery, which rose from 0.73 to 0.95 (+30%) and from 1.66 to 1.83 (+10%), respectively, mainly driven by large investments in research and development, leading to innovations and high-value chemical products and electronic appliances. Nonetheless, Korea faced major declines in (10) Textiles/Clothing, (13) Metals, and (16) Miscellaneous, potentially due to constraints like cotton cropping space, increased labor costs, and a focus on technology-intensive goods.

Table 1 indicates a central finding which is directly related to the testing of $\mathbb{H}_1$; the production structure between Colombia and Korea is deeply complementary, characterized by strong inter-industrial synergy. This represents both an advantage and an obstacle at the same time, since the FTA serves as a catalyst for trade creation but in a differentiated manner across Sector-Groups, thus lacking intra-industrial complementarity.

2.2 Negotiated Points of the FTA

The agreement is regarded as a “high-end” treaty, particularly in terms of market openness and the strength of alliances among the parties. It addresses trade in goods and business promotion, aiming for preferential market access. Signatories commit to granting national treatment to their partners and to progressively reducing or eliminating tariff and non-tariff barriers from the agreement’s effective start date, i.e., July, 2016.

2.2.1 Tariff Measures

Primary Sector Green coffee was granted immediate access, with tariffs rates of 2 to 8%, on instant and mixed preparations set to be eliminated within 0 to 3 years. Textiles also saw tariffs removed immediately or slated for removal within 7 years. Flowers like carnations, roses, and chrysanthemums, were set to be phased out within 3 to 5 years, while banana tariffs will be reduced by 30% over 5 years. Fruits and vegetables customs tariffs were set to be dropped within 5, 7, and 10 years. Moreover, tobacco and cigarette tariffs will be phased out over 10 to 15 years as well as sugar which anticipates the total elimination of its 35% tax rate over 16 years. The agreement also outlines a 16-year period for the removal of the 270% tariff on ethyl alcohol, including a 2-year grace period.⁵

The beef and offal markets are to open in about 19 years, introducing an initial quota favoring fine cuts. Pork and poultry tariffs are scheduled for dismantling within 10 to 16 years. Dairy derivatives, which include whey, cheese, *dulce de leche*, and skimmed milk, will see their tariffs eliminated between 10 to 16 years. Both countries agreed to exclude 200 items such as rice (and rice-containing products), powdered milk, red pepper, and a extended elimination period for 284 sensitive agricultural and sea items.

Secondary Sector Vehicles will see their 35% tariffs abolished within 10 years. 26% of imports including electronic machinery, petrochemical resins, chemicals, steel products, auto parts, and pharmaceuticals, were granted immediate duty-free entry into Colombia. Within 5 years, an additional 18% of products, like tires and small household appliances -excluding larger white goods- will enjoy tariff elimination. 7 years in, 6% more of trade, focusing on iron manufactures, batteries, and similar items, will see tariffs removed. By the 10-year mark, a notable 44% of imports, mainly trucks and appliances, are set for tariff dismantling. 12 years in, refrigerators and freezers will enter tariff-free.

2.2.2 Non-tariff Measures

The FTA also features several dimensions beyond tariff measures. They consist of the introduction of preferential origin rules that reflect the status of products as well as bilateral safeguard measures such as: i) the affirmation of the existing rights in line with the Sanitary and Phytosanitary Measures (SPS), ii) reinforcement of transparency in new technical regulations and amendments to placed guidelines; iii) the formation of a Technical Barriers to Trade committee;⁶ iv) the obligation of Most-Favored-Nation treatment, and temporary entry permission for businessmen and venture investors specially in Small and Medium Enterprises (SMEs); v) adequate legal protection and remedies for artists, performers, technological measures, and rights management, and vi) mutual opening of public procurement markets in central/local government, and state-owned firms.

⁵Table B4 displays the phased timing with which the goods sector was(is) liberalized. Additional data regarding the tariff reduction/elimination is available in this [link](#).

⁶As “[...] no country should be held from adopting/applying SPS measures to protect life or health.”



Although most of the tariff and non-tariff measures have gone by, meaning a vital step forward in liberalizing trade restrictions, they may not be sufficient to produce a causal effect on aggregate trade flows. For instance, the natural geographical distance not only escalates transportation but also complicates logistics. Likewise, the agreed operational framework bring to light the complexities involved in aligning distinct legal systems and business practices that shall be on harmony with consumer preferences (e.g., tastes and interests), languages, and currencies, which could be difficult to implement in practice. In sum, this paper translates $\mathbb{H}_1$ and $\mathbb{H}_2$ into variables and constructs alternative scenarios to assess their impact within the FTA's context and related literature.

3 Empirical Strategy

3.1 Data

3.1.1 Sample Selection

This paper uses the panel-type CEPII Gravity and BACI Databases computed by [Conte et al. \(2022\)](#) and [Gaulier and Zignago \(2024\)](#), respectively. Gravity provides information on cultural, geographic, trade facilitation, and macroeconomic variables, while BACI has Sector-Group trade flow data. Gravity's observation unit consists of the combination of an exporting country (i), an importing country (j), and a year (t), i.e., origin-destination-year (ijt). BACI holds the same structure but now includes an additional level denoting the sector (k). Every country-pair (ij) is represented twice in the datasets depending on the direction of trade; once as ij and once as ji for a given t . The analysis spans a total of 103 countries over the period 2005-2022 at an annual frequency.

The datasets offer three main advantages. First, they grant sufficient coverage before and after the inception of the Colombia-Korea FTA, allowing for control over anticipatory effects and/or particular global trade events. For instance, critical economic emergencies covering from the Mexican Peso crisis (1994) to the European Union expansion (2004), and whose aftermaths had largely dissipated by the beginning of 2005. Second, they reconcile the discrepancy between reported exports (in FOB) and imports (in CIF) value, as well as the double-counting of trade flows in macroeconomic variables such as GDP.⁷ Third, they provide an enriched basis “donor pool” to optimally weight-select both units and variables to estimate the synthetic counterfactuals.

Tables B5 and B6 summarize the main variables in the CEPII datasets. In both tables, columns (1)-(5) present basic statistics for the complete sample, and columns (6)-(8) show the number of observations, the mean, and the standard deviation for the analysis sample, respectively. The analysis sample is obtained by including only Colombia's partners whose total trade volume over the last decade available (2012-2022) exceeded \$100 million. The treatment of zero trade flows observations is addressed in Subsection 3.2.

⁷FOB; Free On Board. CIF; Cost, Insurance and Freight. GDP; Gross Domestic Product.

Turning to the specifics listed in Table B5, column (7) shows that being a member of the World Trade Organization (WTO) (79%) and the General Agreement on Tariffs and Trade (GATT) (88%) is quite prevalent. Almost 20% of the countries share a religion and have no littoral access, i.e., landlocked, while 14% share a common language. The average country has a nominal trade flow value of \$27.44 billion, a population of 57 million, and is approximately 7,600 km distant from its trade partners. Overall, 12% have a currently active FTA, and only 2% share a common terrestrial border. Table B6, column (2) exhibits that, on average, the worldwide trade flow value for each Sector-Grouped level reaches close to \$350 million, weighing little above the 100 million metric tons.

3.1.2 Additional Data Sources

This paper uses additional data sources to build a complementary dataset for full-scale analysis of economic and conventional trade variables. Indicators to describe the country profiles come from the *Ministerio de Comercio, Industria y Turismo* (MinCIT), and [The Atlas of Economic Complexity](#). Aggregated and Sector-Group exports (imports) to (from) Colombia/Korea, available on *Dirección de Impuestos y Aduanas Nacionales* (DIAN) and the [World Integrated Trade Solution](#) website, assist in portraying the hypothesis related to trade creation within the FTA. Data on export destinations to partner countries including regional and non-regional blocs, offered by the *Departamento Administrativo Nacional de Estadística* (DANE), are used to review the trade diversion hypothesis. Trade volume (USD) of traditional and non-traditional exports, provided by DANE, helps in exploring underlying mechanisms such as market diversification. Reports from other governmental entities on the performance and progress of FTA's contribute to the characterization of policy implications, ensuring broad insights for decision-making.

3.2 Gravity Model of Trade

3.2.1 Specifications

The first stage of the assessment follows [Anderson and van Wincoop \(2004\)](#) seminal paper, which retakes the framework proposed by [Anderson and van Wincoop \(2003\)](#). The two papers presented a demand-side gravity model; the first, to intend to tackle the “border puzzle” proposed by [McCallum \(1995\)](#); the second, to effectively estimate Sector-Group trade costs by employing a structural specification. Studies like [Costinot et al. \(2012\)](#), [Eaton and Kortum \(2002\)](#), and [Shikher \(2011\)](#) then expanded on this topics by developing a supply-side structural gravity model but accounting for the Sector-Group.

These contributions, alongside other research, have collectively given a unified and isomorphic system of structural gravity equations ([Arkolakis et al., 2012](#)), highlighting the model's broad applicability across the demand and supply aspects of international trade. The system is also compatible with trade theory and econometric methods.⁸

⁸Variables and parameters description available in Appendix C1.



In general, the gravity model combines consumer preferences for good(s) variety with production and trade principles. Consumers derive utility from a diverse range of goods, while firms operate under increasing returns to scale, producing unique good varieties and setting prices strategically to cover fixed costs. The incorporation of trade barriers, which distinguishes between local and foreign sales, models the worldwide market dynamics under general equilibrium (Larch et al., 2016). In line with the structural gravity model specification, bilateral trade between countries i and j , X_{ij} , is explained by two major factors, the economic size component and the trade cost component, as:

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \quad (3.2.1)$$

where Y_i is i 's income, E_j is j 's expenditure, Y is the world production, τ_{ij} represents bilateral trade costs, Π_i and P_j capture outward and inward multilateral trade resistance terms, i.e., i 's and j 's ease of market access, and σ is the elasticity of substitution among goods from all countries. The sectoral analysis is done by indexing equation (3.2.1) to k , which remains consistent even if omitted (Anderson and van Wincoop, 2004).

Drawing on the multiplicative form of equation (3.2.1), and assuming it holds across each year, it is feasible to log-linearize it and index it to t . This transformation also includes the addition of a constant term, Θ , a vector of regressors to account for the trade creation and trade diversion effects of the Colombia-Korea FTA (set in accordance with the gravity model literature), Δ_{ijt} , and a stochastic error term, ε_{ijt} .

Hence, it yields in the canonical gravity specification for panel data:

$$\begin{aligned} \ln X_{ijt} = & \Theta + \beta_1 \ln Y_{it} + \beta_2 \ln E_{jt} - \beta_3 \ln Y_t \\ & + (1 - \sigma) [\ln \tau_{ij} - \ln \Pi_{it} - \ln P_{jt}] + \Delta'_{ijt} \Phi + \varepsilon_{ijt} \end{aligned} \quad (3.2.2)$$

The variables Y_{it} , E_{jt} , and Y_t can be modeled using exporter-time, importer-time, and time fixed effects, respectively, to account for common time-variant factors without imposing any constraints (Adarov, 2022) or by directly computing the related exporter and importer GDP values. However, the main challenge in obtaining unbiased estimators for equation (3.2.2) lies in identifying how to quantify the trade cost term; owing to the non-visibility of bilateral trade costs (time-invariant) and multilateral resistances.

First, measuring precisely bilateral trade costs is impractical (Bacchetta et al., 2012); thus, a number of proxy variables are used as controls in the regression. The functional form adheres to the standards defined by the gravity model literature and appends extra variables listed in the Gravity Database to enhance robustness, as follows:

$$\begin{aligned} \ln \tau_{ijt} = & \gamma_1 \ln(H - \text{Distance}_{ij}) + \gamma_2 \text{Border}_{ij} + \gamma_3 \text{Colony}_{ij} + \gamma_4 \text{Religion}_{ij} \\ & + \gamma_5 \text{Language}_{ij} + \gamma_6 \text{Legal}_{ij} + \gamma_7 \text{Landlocked}_{ij} + \gamma_8 \text{FTA}_{ijt} + \gamma_9 \text{WTO}_{ijt} \end{aligned} \quad (3.2.3)$$

⁹For the detailed glossary of the model refer to Appendix C1.

where $(H - Distance_{ij})$ is the population-weighted average distance (harmonic mean) in km.¹⁰ While $Border_{ij}$, $Colony_{ij}$, $Religion_{ij}$, $Language_{ij}$, $Legal_{ij}$, $Landlocked_{ij}$, FTA_{ijt} , and WTO_{ijt} are dummy variables denoting whether two countries share a common border, colonial history, religion, official language, legal origin (siblings) and whether one or both are landlocked, members of an active FTA and the WTO, respectively.

Second, not controlling for the multilateral resistance terms will result in committing the “gold-medal mistake” as they lead to endogeneity (Baldwin and Taglioni, 2006). The gravity model literature offers two well-recognized methods to estimate Π_{it} and P_{it} . One employs exporter-time and importer-time fixed effects with panel data (Olivero and Yotov, 2012), thereby dropping country-specific covariates.

The other employs “remoteness indexes” from weighted averages of bilateral distances and GDPs as: $Remoteness_{it} = \sum_{j=1}^C \frac{Distance_{ij}}{GDP_{jt}/GDP_t}$ and $Remoteness_{jt} = \sum_{i=1}^C \frac{Distance_{ij}}{GDP_{it}/GDP_t}$, respectively, (Wei, 1996). This paper adopts both suggestions to estimate bilateral trade costs and multilateral resistances to contrast them with the remaining results.

The variables included in Δ_{ijt} are split into two subsets totaling 11 variables. The first captures the trade creation effects, i.e., gains from trade, of the FTA (3 variables); the second captures the trade diversion effects, i.e., substitution of imports, experienced by Colombia and Korea following the FTA’s implementation (8 variables).

To build on the assessment, this paper first estimates the aggregate trade flow effects before delving into the differentiated sectoral effects that result from heterogeneous production capabilities and competitive advantages of each country.

Trade Creation As Colombia and/or Korea engage in mutual exchange, resources are optimally allocated in line with each country’s comparative advantage. The agreement, by reducing or eliminating tariff barriers, accelerates this transition, thereby stimulating increases in the volume of trade between them. The specifications are detailed here:

- (1) $FTA\ COL-KOR_{ijt}$: 1 for COL and KOR as members of the FTA; 0 otherwise.
- (2) $TF\ COL-KOR_{ijt}$: 1 if COL is the exporter to KOR within the FTA; 0 otherwise.
- (3) $TF\ KOR-COL_{ijt}$: 1 if KOR is the exporter to COL within the FTA; 0 otherwise.

where $FTA\ COL-KOR$ picks up the average treatment effect on bilateral trade flows between COL and KOR under the FTA, i.e., symmetric approach. Then, $TF\ COL-KOR$ and $TF\ KOR-COL$ picks up the individual treatment effects on COL exports to KOR and KOR exports to COL, respectively, by considering the possibility that bilateral trade effects may differ based on the direction of trade, i.e., asymmetric approach.¹¹

¹⁰Head and Mayer (2010) showed that $Distance_{ij}$ is given by $d_{ij} = \left(\sum_{m \in i} \frac{pop_m}{pop_i} \sum_{n \in j} \frac{pop_n}{pop_j} \epsilon d_{mn} \right)^{\frac{1}{\epsilon}}$, where pop denotes the population, subscripts m and n are cities, d_{mn} is the geographic distance between them (in km), and ϵ is the distance elasticity of trade flows (≈ -1).

¹¹Variables (1)-(3) shall not be computed together due to collinearity with FTA_{ijt} ; combinations of (1) excluding (2) and (3), or (2) and (3) excluding (1) are only allowed.



Trade Diversion In its strictest sense, occurs when either or both countries start to import goods from their FTA partner rather than from more efficient producers outside the treaty. In its relaxed sense; if a country favors imports from an FTA member, non-members might also reduce their imports from that member, thus affecting its exports. This paper accounts for both direct and indirect impacts of trade diversion. Hence, the subset of regressors related to the trade diversion effects comprises the linear combination of Colombia's and Korea's trade flows with third-party regions (*REG*), as:¹²

(1/2) *IMP COL-REG_{ijt}*: 1 if COL is the importer from *LAC/ESEA*; 0 otherwise.

(3/4) *IMP KOR-REG_{ijt}*: 1 if KOR is the importer from *LAC/ESEA*; 0 otherwise.

(5/6) *EXP COL-REG_{ijt}*: 1 if COL is the exporter to *LAC/ESEA*; 0 otherwise.

(7/8) *EXP COL-REG_{ijt}*: 1 if KOR is the exporter to *LAC/ESEA*; 0 otherwise.

3.2.2 Threats to Identification

There are still other empirical challenges in choosing the most suitable estimator(s) for the data and the context ([Larch et al., 2016](#)). The first challenge revolves around the presence of zero trade data when using Panel Fixed Effects (PFE) with Ordinary Least Squares (OLS) because observations are dropped when the trade value is set into a logarithmic form. It is especially noticeable the more disaggregated the observational units are.

The second challenge is the existence of heteroskedasticity in exports, imports, and GDP values that produce biased and inconsistent estimators of the elasticities if the gravity model is estimated by OLS. Finally, the third challenge lies in the endogeneity of FTAs and (all) trade policies, as they may suffer from “reverse causality” since, everything equal, a country tends to ease trade restrictions with another one that is already a key trading partner, potentially overlooking the effects of the FTA.

This paper addresses these threats to identification by: i) employing a Poisson Pseudo-Maximum Likelihood (PPML) estimator to tackle the first and second challenges. [Santos-Silva and Tenreyro \(2006\)](#) showed that PPML generates consistent estimators since it leverages a multiplicative form rather than a log-linear, and they remain robust against different patterns of heteroskedasticity in GDP data, and ii) employing exporter-importer fixed effects as well as country-pair clustered standard errors, which will absorb all time-invariant covariates, including linkages between the endogenous trade policy variables and the error term ([Baier and Bergstrand, 2007](#); [Dai et al., 2014](#)).

This paper also accounts for intra-national trade data as best practice. Although it ensures consistency with the gravity model theory where consumers choose between both domestic and foreign good varieties, and firms produce accordingly to effective demand ([Larch et al., 2016](#)), it also corrects for biases in the analysis of FTAs impacts on trade flows stemming from unobserved country-pair heterogeneity ([Bergstrand et al., 2015](#)).

¹²Table B7 compares relevant variables of countries in the *ESEA* region with *LAC* economies.

The final model is set once considering all threats to identification of equation (3.2.2):

$$X_{ijt} = \exp(\Sigma_{it} + Y_{jt} + \Omega_{ij} + \Delta'_{ijt}\Phi + \Gamma'_{ijt}\Lambda) + \varepsilon_{ijt} \quad (3.2.4)$$

where Σ_{it} and Y_{jt} are the exporter-time and importer-time fixed effects, respectively, and Ω_{ij} is the country-pair fixed effect. Γ_{ijt} includes two control variables for time-varying drivers of bilateral trade flows: FTA_{ijt} (active) and WTO_{ijt} (membership).

To test H_1 and H_2 , this paper first estimates both the aggregate trade creation and trade diversion effects, then indexes equation (3.2.4) to k to examine the sector-specific effects. This approach reveals how the FTA has differentially benefited or disadvantaged sectors. Alternative specifications employing the canonical gravity model variables and other combinations of fixed effects are also estimated. Finally, to assess the impact of multidimensional distances, while equation (3.2.3) captures indirect effects through trade costs, a discussion with extra data and qualitative illustrations is included.

3.3 Synthetic Counterfactuals

The second stage of the assessment employs a Synthetic Control Method (SCM) developed by [Abadie and Gardeazabal \(2003\)](#) and [Abadie et al. \(2010\)](#); helpful in comparative case studies. The SCM is used to estimate both aggregate and Sector-Group trade flows that would have been observed in the absence of the agreement. This methodology relies on a weighted average of the outcome of potential control units to construct the counterfactual outcome of the treated unit(s). The weights are optimally chosen so that, on average, the estimated pre-treatment outcome and observed characteristics of the synthetic control are similar to those actually observed in the treated unit(s). In the FTA context, the units are country-pairs, and the trade policy is the agreement becoming effective.

One of the advantages of SCM to address selection bias is that it allows the effect of unobserved confounders to vary with time, as opposed to Difference in Difference (DiD) method. This enables more precise quantification of the effects, by considering not only the variations before and after the FTA implementation but also those influences that remain constant over the time frame that may exhibit heterogeneity across units.

The treated units of trade creation effects are COL-KOR and KOR-COL. In parallel, the treated units of trade diversion effects involve country-pairs with COL (KOR) as the importer to non-treaty regions, as well as COL (KOR) as the exporter from non-treaty regions. The synthetic counterfactual outcome is thus the presumed post-treatment trade flow value that would have been observed if the FTA had not been established.

The analysis sample consists of $J + 1$ units, supposing the first unit, $i = 1$, is exposed to treatment, while the remaining units $i = 2, \dots, J + 1$ are not, thereby serving as a potential control group. Let Y_i^0 denote the outcome that is observed for unit i in the absence of treatment $\forall i \in [1, J + 1]$ and period $t \in [1, T]$, which includes post-treatment period $[T_0 + 1; T]$. Let Y_i^1 denote the outcome for unit i at time t under treatment.



By design, $Y_i^0 = 1$ for the pre-treatment period $t \in [1, T_0] \forall i \in [1, J + 1]$. In the post-treatment period, $\delta_{it} = Y_{it}^1 - Y_{it}^0$ is the impact of treatment on unit i at time t . Since only unit $i = 1$ is subject to treatment and not until $t > T_0$, then:

$$Y_{it}^1 = Y_{it}^0 + \delta_{it}D_{it}, \text{ where } D_{it} = \begin{cases} 1 & \text{for } i = 1, t > T_0 \\ 0 & \text{otherwise} \end{cases}$$

All outcomes are observed for all periods with the exception of Y_i^0 for $t > T_0$. [Abadie et al. \(2010\)](#) approach assumes that Y_i^0 is determined by the following factor model

$$Y_{it}^0 = \eta_t + Z_i' \lambda_t + \chi_i' \phi_t + u_{it} \quad (3.3.1)$$

The main idea of equation (3.3.1) is based on finding an optimized vector of weights, $W = (w_2, \dots, w_{J+1})'$, such that $Y_{it} \approx \sum_{j=2}^{J+1} w_j Y_{jt}$ and $Z_1 \approx \sum_{j=2}^{J+1} w_j Z_j$. Each value of W represents a potential synthetic control for the treated unit, that is, a particular weighted average of control units from the donor pool. As the optimization condition above is overly restrictive, an optimal weight vector is chosen to closely satisfy the condition. [Abadie and Gardeazabal \(2003\)](#) propose to minimize the pseudo-distance between the pre-treatment characteristics of the treated unit, X_1 , and the synthetic control group, $X_0 W$:

$$\min || X_1 - X_0 W ||, \text{ s. t. } w_j \geq 0 \wedge \sum_{j=2}^{J+1} w_j \text{ for } j = 2, \dots, J + 1$$

Once W is selected, the estimated treatment effect is: $\hat{\delta}_{1t} = Y_{1t}^1 - \sum_{j=2}^{J+1} \hat{w}_j Y_{jt}; t > T_0$.

The gravity model serves as a natural reference framework for selecting the relevant covariates that constitute Z_i (see [Hannan, 2016](#)). In this sense, the optimization procedure for X_1 and X_0 not only adds the outcome variable, but also uses all canonical gravity model variables of equations (3.2.3) and (3.2.4) as pre-treatment characteristics. These are also added with others available in the Gravity Database and custom variables. This implies that synthetic counterfactuals are being estimated by incorporating the gravity model's results as input. Thus, this allows for contrasting them to verify and discuss the validity of the hypotheses in terms of directionality, magnitude, and consistency.

3.3.1 Donor Pool Selection

The motivation behind the use of SCM is to mitigate the extrapolation bias that may appear when units with different pre-treatment characteristics are combined employing a traditional adjustment (e.g., linear regression with panel data). Nonetheless, the SCM also interpolates by employing a convex weighted average of the non-treated units.

This paper addresses this threat to identification by restricting the donor pool to a subset of units mostly similar to the treated units in terms of X_1 . [Abadie et al. \(2010\)](#) showed that to minimize biases from interpolation across regions with divergent characteristics, one should restrict the donor pool to regions with “similar characteristics to the region exposed to the event or intervention of interest.”

Due to the high heterogeneity of countries in the analysis sample, it becomes complex to identify similar units to Colombia and Korea, so the donor pool is limited to country-pairs in line with the regions detailed in Subsection 3.2, alongside criteria to ensure they are comparable to the treated units. The donor pool captures the units satisfying:

1. Both countries in the unit belong to the *LAC* and *ESEA* regions.¹³
2. Average trade flow value between 2005–2015 is within one standard deviation from that of the treated unit.
3. Pre-treatment average absolute value of the “gravity ratio”: $\frac{\hat{\beta}_1 \ln GDP_{it} \times \hat{\beta}_2 \ln GDP_{jt}}{\hat{\gamma}_1 \ln(H - Distance_{ij})}$ is within one standard deviation from that of the treated unit.¹⁴

For each treated unit, the specific donor pool sample is restricted to a group of units in its neighborhood in the gravity model sense ([Adarov, 2022](#)). To further improve precision, COL-KOR is computed with *LAC-ESEA* units, while KOR-COL with *ESEA-LAC* units. Figure D1 shows the donor pool’s size is large enough to secure unbiased and consistent synthetic estimations, thereby alleviating the interpolation bias.

4 Results and Discussion

This section analyzes aggregate and Sector-Group level estimates using the gravity model of trade. It then assesses synthetic counterfactuals, focusing on trade creation and trade diversion effects, and discusses the impact of multidimensional distances as barriers to goods exchange, providing additional perspectives on the findings.

4.1 Evidence on Trade Creation and Trade Diversion

4.1.1 Aggregate Analysis: Did It Work?

Gravity Model of Trade Table 2 presents the regression estimates for equations (3.2.3) and (3.2.5) for the analysis sample. Columns (1)-(5) show the results using a PPML estimator, while columns (6)-(8) show the results using a PFE estimator.¹⁵

¹³Including Chile and/or Peru in the donor pool sample does not pose a concern, as their trade diversion effects towards *ESEA* countries -which challenges the identification assumption- had already dissipated by the time the FTA came into effect ([Han, 2011](#); [Im et al., 2017](#); [Yoon, 2022](#)).

¹⁴ $\hat{\beta}_1, \hat{\beta}_2$, and $\hat{\gamma}_1$ coefficients are obtained after estimating equation (3.2.3).

¹⁵In PPML, coefficients for continuous and dummy variables show the $\Delta\%$ in X_{ijt} per unit increase in predictors: $[e^{\beta} - 1] \times 100$. In PFE, for continuous variables, coefficients show the direct elasticity with respect to X_{ijt} : $\hat{\beta}$, and for dummy variables, they show the $\Delta\%$ in X_{ijt} when activated: $[e^{\beta} - 1] \times 100$. The latter is employed for comparison purposes as it has been the literature-standard.

Table 2: Gravity Model Estimates

Variable	PPML					PFE		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\ln GDP_{it}$	0.528*** (0.047)					0.446*** (0.036)		
$\ln GDP_{jt}$	0.568*** (0.045)					0.562*** (0.034)		
$\ln H - Distance_{ij}$	-0.746*** (0.029)	-0.749*** (0.029)	-0.749*** (0.029)			-1.342*** (0.026)		
$Border_{ij}$	0.366*** (0.072)	0.355*** (0.072)	0.355*** (0.072)			0.026 (0.124)		
$Colony_{ij}$	0.605*** (0.164)	0.618*** (0.162)	0.618*** (0.162)			0.246** (0.108)		
$Religion_{ij}$	0.005 (0.095)	0.007 (0.095)	0.007 (0.095)			0.293*** (0.073)		
$Language_{ij}$	0.104 (0.070)	0.101 (0.069)	0.101 (0.069)			0.781*** (0.056)		
$Legal_{ij}$	-0.046 (0.139)	-0.041 (0.136)	-0.041 (0.136)			0.153 (0.115)		
$Landlocked_{ij}$	-0.070 (0.187)	-0.069 (0.186)	-0.069 (0.186)			-0.019 (0.190)		
$\ln Remoteness_{it}$	0.820*** (0.226)					-0.526*** (0.198)		
$\ln Remoteness_{jt}$	0.103 (0.222)					-1.425*** (0.206)		
FTA_{ijt}	0.216*** (0.058)	0.229*** (0.060)	0.229*** (0.060)	0.156*** (0.022)	0.155*** (0.022)	0.284*** (0.040)	-0.011 (0.027)	-0.011 (0.027)
WTO_{ijt}	-0.957*** (0.226)	-1.024*** (0.294)	-1.024*** (0.294)	0.135 (0.110)	0.135 (0.110)	-0.112 (0.283)	-0.055 (0.196)	-0.055 (0.196)

To be continued (next page)

<i>FTA COL – KOR_{ijt}</i>		0.232 (0.172)		0.010 (0.361)		0.323 (0.312)	-0.093 (0.380)	
<i>TF COL – KOR_{ijt}</i>	0.052 (0.212)		0.035 (0.174)		1.019*** (0.115)			0.435*** (0.151)
<i>TF KOR – COL_{ijt}</i>	0.189 (0.134)		0.374** (0.153)		-0.351*** (0.056)			-0.622*** (0.131)
<i>IMP COL – LAC_{ijt}</i>	0.164 (0.143)	0.358** (0.175)	0.364** (0.178)	-0.118 (0.116)	-0.136 (0.117)	-0.407 (0.253)	-0.384** (0.160)	-0.393** (0.160)
<i>IMP COL – ESEA_{ijt}</i>	0.536*** (0.204)	0.697*** (0.236)	0.702*** (0.237)	0.248*** (0.058)	0.231*** (0.061)	0.695*** (0.221)	0.282 (0.266)	0.274 (0.266)
<i>IMP KOR – LAC_{ijt}</i>	0.520* (0.274)	0.145 (0.252)	0.144 (0.252)	0.231 (0.172)	0.233 (0.172)	0.483* (0.257)	0.095 (0.139)	0.103 (0.140)
<i>IMP KOR – ESEA_{ijt}</i>	-0.593*** (0.160)	-1.001*** (0.199)	-1.002*** (0.200)	-0.003 (0.071)	-0.001 (0.071)	-1.357** (0.667)	-0.160 (0.202)	-0.152 (0.202)
<i>EXP COL – LAC_{ijt}</i>	0.126 (0.148)	0.525** (0.255)	0.519** (0.255)	0.438** (0.181)	0.454** (0.179)	0.015 (0.159)	-0.070 (0.177)	-0.062 (0.177)
<i>EXP COL – ESEA_{ijt}</i>	-0.178 (0.268)	0.188 (0.268)	0.182 (0.269)	0.356*** (0.111)	0.373*** (0.107)	-0.187 (0.274)	0.122 (0.374)	0.130 (0.374)
<i>EXP KOR – LAC_{ijt}</i>	0.536*** (0.203)	0.515*** (0.171)	0.516*** (0.171)	-0.186* (0.103)	-0.188* (0.103)	0.473*** (0.144)	-0.196* (0.117)	-0.204* (0.117)
<i>EXP KOR – ESEA_{ijt}</i>	-0.231** (0.098)	-0.246 (0.163)	-0.246 (0.163)	-0.032 (0.093)	-0.034 (0.093)	-1.357*** (0.411)	-0.119 (0.127)	-0.127 (0.127)
<i>Constant</i>	-3.982** (2.508)	23.274*** (0.389)	23.274*** (0.389)	16.515*** (0.109)	16.515*** (0.109)	11.262*** (1.903)	10.208*** (0.196)	10.208*** (0.196)
Exporter-Time FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Importer-Time FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Exporter-Importer FE	No	No	No	Yes	Yes	No	Yes	Yes
Exporter, Importer and Time FE	Yes	No	No	No	No	Yes	No	No
Observations	131,905	131,905	131,905	143,163	143,163	131,905	143,163	143,163
Clusters	8,330	8,330	8,330	9,077	9,077	8,330	9,077	9,077

Notes: Columns (1)-(5) present the results using a Poisson Pseudo-Maximum Likelihood (PPML) estimator based on multiplicative form, while columns (6)-(8) present the results using a Panel Fixed Effects (PFE) estimator based on log-log form, both for the analysis sample (103 countries between 2005-2021) in CEPII's Gravity Database. *FTA_{ijt}* excludes the Colombia-Korea FTA to avoid collinearity and control for endogenous trade policy. Standard errors clustered by country-pair in parenthesis. *p<0.10, **p<0.05, ***p<0.01.



The results of greatest interest for this paper are reported in columns (4), (5), (7), and (8), which employ three-way fixed effects, i.e., exporter-time, importer-time, and exporter-importer, since trade creation and trade diversion effects might be overestimated due to the endogeneity of unobserved country-pair relationships that even explanatory variables included in the canonical gravity specification are unable to capture.

Trade Creation Columns (4) and (7) show a statistically insignificant coefficient for *FTA COL-KOR*, implying that there were no aggregate trade flow increases as a result of the FTA. The analysis conducted in Figure 1a provided a preliminary notion that the symmetric effect was unnoticeable. Columns (5) and (8), conversely, show economically and statistically significant coefficients for *TF COL-KOR* and *TF KOR-COL* asymmetric trade creation effects. Their magnitudes suggest an increase in trade flows from Colombia to Korea by 54-177% and a 28-45% decrease in trade flows from Korea to Colombia.

Trade Diversion Shift effects are implied by the negative sign(s) of *IMP COL/KOR-REG*, i.e., import diversion, or *EXP COL/KOR-REG*, i.e., export diversion, coefficients. There are no statistically significant negative coefficients in either of the two specifications regarding imports to Colombia or Korea from *LAC* or *ESEA*. In its strictest sense, no import substitution from partners outside the FTA that belong to the regions Colombia and Korea usually trade with is happening. Yet, once relaxing the sense, *EXP KOR-LAC* negative coefficient suggests a decrease of exports from Korea to *LAC* by 17%.

Insights The FTA seems to have had no symmetric effect on trade creation, but rather a significant asymmetric one and scant empirical proof exists of trade diversion so to confute H_2 . One possible reason for the lack of economic impact could be the placed trade relationships and optimized logistics networks. The maturity of these channels might have weakened the aggregate results, allowing trade patterns to continue unaltered.

Synthetic Counterfactuals Table 3 lists the country-pairs selected according to the matching method to build the synthetic counterfactual estimates for COL-KOR and KOR-COL trade flows and their associated weights.

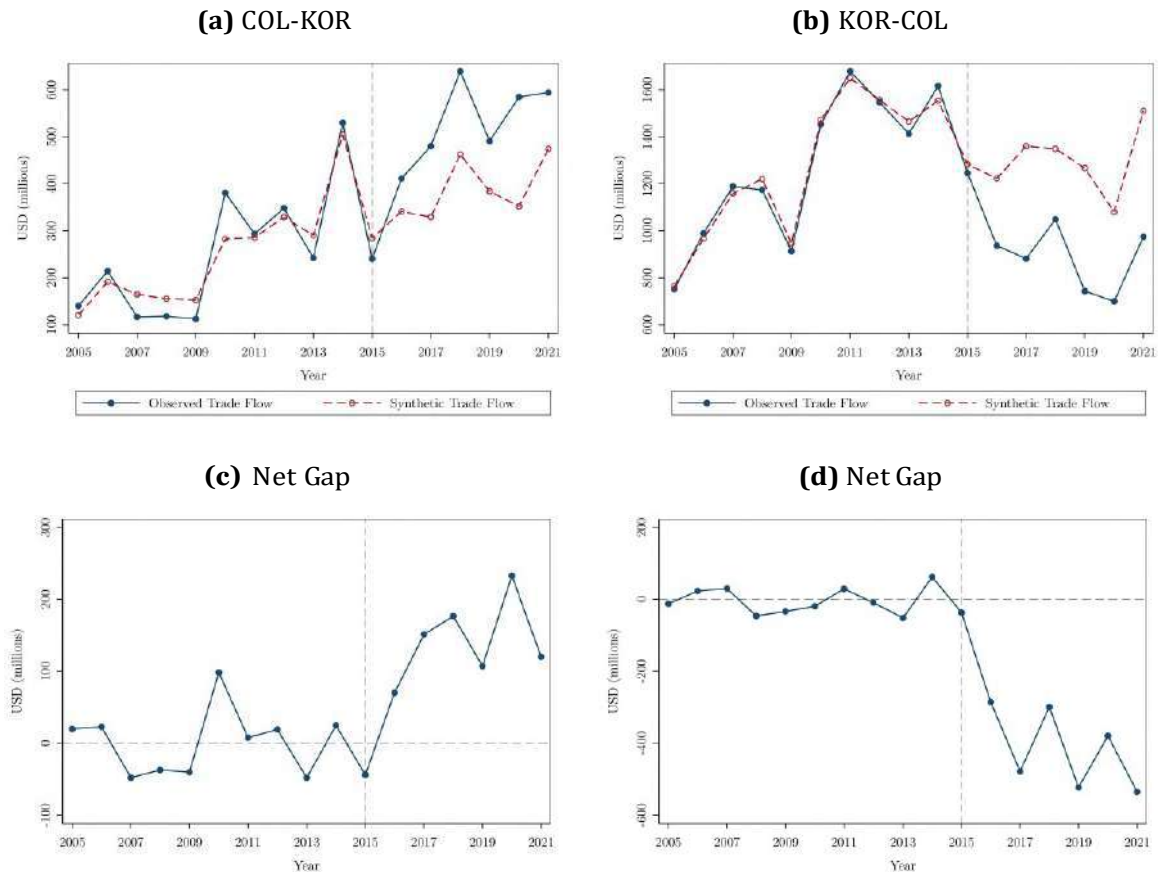
Table 3: Synthetic COL-KOR and KOR-COL Donor Pool Units Weights

COL-KOR		KOR-COL	
Unit _{ij}	Weight	Unit _{ij}	Weight
CHL-THA	0.315	IDN-BRA	0.488
ECU-SGP	0.301	JPN-CUB	0.286
HND-CHN	0.137	JPN-VEN	0.105
MEX-SGP	0.128	JPN-MEX	0.046
CHL-HKG	0.062	CHN-BOL	0.038
ECU-JPN	0.057	IDN-CHL	0.037

Notes: Beneath each treated unit name, the selected donor pool units and its weights. ISO 3166-1 alfa-3 country codes are: CHL, Chile; THA, Thailand; ECU, Ecuador; SGP, Singapore; HND, Honduras; CHN, China; MEX, Mexico; HKG, Hong Kong; JPN, Japan; IDN, Indonesia; BRA, Brazil; CUB, Cuba; VEN, Venezuela, VEN, and BOL, Bolivia.

Synthetic counterfactual estimate for COL-KOR features: Chile, Honduras, Ecuador, and Mexico, while for KOR-COL features: Indonesia, Japan and China. These selected donor units (i.e., exporters) represent a reasonable list of geographically close and economically comparable countries to the actual treated units. Notably, they all share the Pacific coastline, which is crucial for the maritime trade as it facilitates shipping.¹⁶

Figure 2: Synthetic COL-KOR and KOR-COL Estimates, Trade Creation



Notes: Panels (a) and (b) plot the observed -blue solid line- and synthetic counterfactual -red dashed line- trade flows, while Panels (c) and (d) plot the net gap in USD (millions) for each treated unit between 2005-2021. A time threshold is set to 2015 (synthetic 2016 is predicted).

Trade Creation Figure 2 displays actual and synthetic counterfactual trade flow for COL-KOR and KOR-COL. At first glance, Figure 2a showcases some clutter in the data fitting of the synthetic trade flow line prior to 2011; however, it quickly adjusted by 2015. Still, Colombia displays a net positive effect on trade flows due to the FTA (see Figure 2c). One year in until the series's end, the observed trade flow line constitutes an upper bound of the synthetic. Moreover, between 2016-2018, the trend is purely increasing because of immediate tariff eliminations, taking a brief fall in 2019 but recovering after. By the end of 2020 the gap has grown to almost \$250 million which is the monetary value of trade creation effect in the presence of the policy.

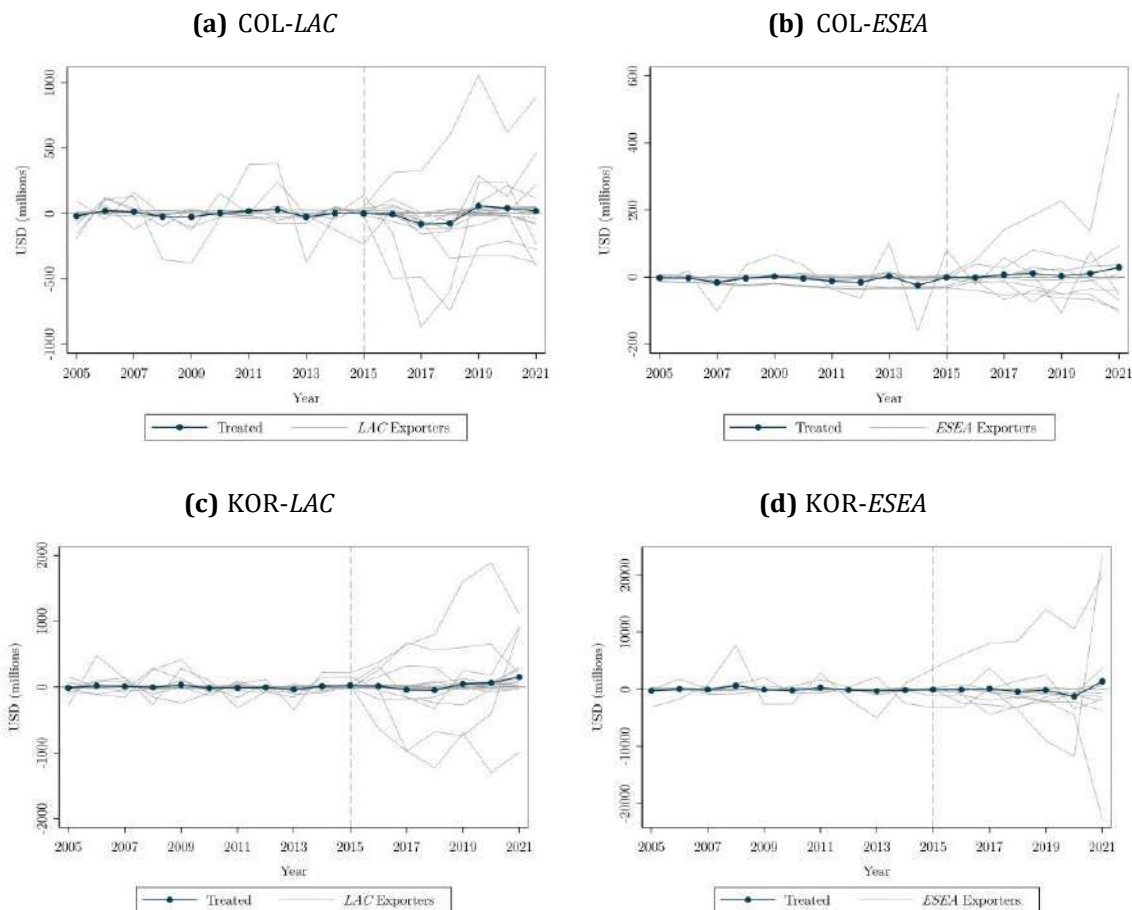
¹⁶To illustrate the SCM success at finding a weighted basket of country-pairs that are observationally similar to COL-KOR and KOR-COL prior to 2016, Table D1 compares the average value of each predictor variable used and their synthetic counterfactual estimate.



Similarly, Figure 2b depicts an immediate divergence after 2015 with an abrupt drop of an average \$420 million in Korea's trade flows to Colombia. Here, the synthetic trade flow line now closely tracks the observed for all pre-treatment periods which implies that this reduction does not occur before the FTA effectively takes place (see Figure 2d). From 2016 onwards, now, the observed trade flow has become a lower bound of the synthetic, therefore constituting a net negative trade creation effect for all post-treatment periods. Until 2017, there was a remarkable negative trend that seemed to recover in losses in 2018 and 2020, but in 2021 it fell to -\$535 million; the lowest point in the series.

These findings point out an intensive use of the FTA by Colombia, but not by Korea which follows Bergstrand (1990) conclusion on treaties having asymmetric impacts where countries benefit heterogeneously. When taking the mean differences between the observed and synthetic trade flows in the period 2016-2021, the average treatment effect suggests a net 37% increase for COL-KOR and a net 32% decrease for KOR-COL, both in terms of trade creation, as a result of the policy.

Figure 3: Synthetic COL-REG and KOR-REG Estimates, Trade Diversion



Notes: Panels (a)-(d) plot the net gap between the observed and synthetic trade flows in USD (millions) for Colombia and Korea to LAC (19 countries) and ESEA (12 countries) -light gray solid lines- and the mean treatment effect -blue solid line- computed as $\sum_n \frac{\hat{\delta}_{nt}}{N}$, where $N=\#$ accounted exporters between 2005-2021. The list of countries for each panel is available in the notes of Table B7. A time threshold is set to 2015 (synthetic 2016 is predicted).

Trade Diversion Estimation of trade diversion effects is more complicated on account of a large number of trading partners outside the bloc with diverse impacts of the FTA's regulations on each. To compute them, this paper identifies the exporters to each country, based on the region(s) of origin, and uses them sequentially as a treated unit. To rephrase, synthetic counterfactual lines are estimated individually for each country-pair from which Colombia or Korea imports, belonging to either *LAC* or *ESEA*.

Figure 3 plots the net gaps between the actual and synthetic counterfactual trade flows for each importer country and the computed mean effect. No clear-cut uniform direction of change is seen; while a range of countries displays strong signs of trade diversion, other countries, on the contrary, exhibit an improvement in trade flows. The negative impact in imports from countries outside the treaty is consistent with the general expectations for trade-diverting customs unions (Krein, 1959), yet its positive impact could be the result of tangible progress in the bilateral trade restrictiveness of the FTA.

Figure 3a shows a slight trend towards trade diversion from Colombia to *LAC* between 2016-2018, but it fades in the following years. There is also no clear indication of an import shift between Korea and *LAC* or *ESEA*, since the mean treatment effect remains close to zero throughout all post-treatment periods, even showing an increase in 2021 (see Figures 3c and 3d). In turn, a nuanced but significant growth in Colombia's imports from *ESEA* is seen in Figure 3b, resulting in a trade creation effect of around \$240 million.

Insights The FTA led Colombia to a sustained increment of trade flows to Korea, but not conversely; as Korea might have experienced better conditions without the FTA. There are still no substantial effects of trade diversion observed since neither of the two countries has reduced their imports from *LAC* or *ESEA* to redirect them to their partner. The results conform to the estimates of the gravity model. Although not exhaustive, they offer an aggregate view in the impact assessment of the FTA's effects so the breakdown by industries is necessary to understand the subjacent drivers.

4.1.2 Sector-Group Analysis: Who Benefited?

Gravity Model of Trade Tables 4 and 5 present the regression estimates for equation (3.2.5) under the asymmetric approach for the analysis sample. Columns (1)-(16) show the results using a PPML estimator, and employing three-way fixed effects, for each Sector-Group following the grouping of Table 1.

Trade Creation Few of the trade creation effects are aligned with the negotiated tariff measures within the FTA. The positive sign and statistically significant coefficient for *TF COL-KOR* for (2) Vegetable suggest that Colombia increased its trade flows to Korea by 43%. Yet, (3) Foodstuffs, (6) Chemicals, and (10) Textiles/Clothing exhibit no trade flow increase even though the FTA offered preferential access measures for confectionery products, cosmetics, cotton garments, and leather goods. Figures A3a and A3b confirm these results as one can observe that immediate elimination of tariffs on coffee, fruits, and vegetables is related to the upward trend of trade flows value and market share.

Table 4: Gravity Model Estimates by Sector-Group, (1)-(8)

Variable	Sector-Group							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$TF\ COL - KOR^k_{ijt}$	-0.491 (0.593)	0.357*** (0.131)	0.084 (0.146)	-2.665*** (0.645)	1.357*** (0.247)	0.215 (0.145)	1.146*** (0.251)	-0.850*** (0.168)
$TF\ KOR - COL^k_{ijt}$	0.964** (0.413)	0.187 (0.153)	-0.023 (0.141)	1.262** (0.515)	0.445 (0.571)	-0.529*** (0.128)	-0.443*** (0.077)	-1.291*** (0.239)
$IMP\ COL - LAC^k_{ijt}$	-0.139 (0.285)	-0.502*** (0.133)	-0.355** (0.172)	-1.099*** (0.414)	-0.433 (0.589)	-0.290*** (0.104)	-0.091 (0.255)	-0.333** (0.137)
$IMP\ COL - ESEA^k_{ijt}$	0.437 (0.304)	-0.330*** (0.112)	-0.265 (0.179)	0.007 (0.390)	0.576 (0.840)	0.045 (0.074)	-0.020 (0.129)	0.228** (0.101)
$IMP\ KOR - LAC^k_{ijt}$	-0.154 (0.178)	0.334 (0.293)	0.289 (0.210)	-0.145 (0.135)	1.829*** (0.528)	0.568*** (0.105)	0.139 (0.119)	-0.837*** (0.315)
$IMP\ KOR - ESEA^k_{ijt}$	-0.433** (0.209)	-0.277** (0.101)	-0.070 (0.130)	-0.388 (0.243)	-0.220 (0.372)	-0.063 (0.097)	-0.192 (0.124)	-0.210* (0.125)
$EXP\ COL - LAC^k_{ijt}$	-1.069 (0.687)	0.264 (0.185)	-0.249* (0.129)	0.119 (0.675)	0.652** (0.329)	0.318** (0.152)	0.197 (0.272)	-0.020 (0.217)
$EXP\ COL - ESEA^k_{ijt}$	0.056 (0.634)	-0.239* (0.138)	0.264** (0.133)	1.398 (0.968)	0.147 (0.238)	0.108 (0.209)	0.020 (0.270)	-0.280 (0.275)
$EXP\ KOR - LAC^k_{ijt}$	0.595 (0.386)	-0.143 (0.375)	0.455** (0.204)	1.550*** (0.524)	-0.328 (0.544)	-0.411*** (0.144)	-0.294* (0.158)	-0.744*** (0.275)
$EXP\ KOR - ESEA^k_{ijt}$	-0.112 (0.422)	-0.585*** (0.188)	0.005 (0.167)	1.386*** (0.464)	-0.517** (0.263)	-0.769*** (0.146)	-0.230*** (0.077)	-0.506* (0.285)
<i>Constant</i>	12.990*** (0.292)	13.398*** (0.273)	13.440*** (0.175)	14.720*** (0.226)	14.856*** (0.249)	13.595*** (0.099)	13.361*** (0.109)	11.739*** (0.185)
Observations	75,623	91,020	99,478	63,578	65,414	101,113	100,630	81,181
Clusters	5,979	6,680	7,094	5,284	5,445	7,221	7,247	6,355
Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1)-(8) present the results using a Poisson Pseudo-Maximum Likelihood (PPML) estimator based on multiplicative form for the analysis sample (100 countries between 2005-2022) in CEPII's BACI Database. Sector-Groups (k) considered were: (1) Animal, (2) Vegetable, (3) Foodstuffs, (4) Minerals, (5) Fuels, (6) Chemicals, (7) Plastic/Rubber, and (8) Hides/Skins. Others include two control variables for time-varying drivers of bilateral trade flows: FTA_{ijt} and WTO_{ijt} , and three-way fixed effects, i.e., exporter-time, importer-time, and exporter-importer. Standard errors clustered by country-pair in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Gravity Model Estimates by Sector-Group, (9)-(16)

Variable	Sector-Group							
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
$TF\ COL - KOR^{k}_{ijt}$	1.386*** (0.229)	-0.266* (0.160)	0.330 (0.372)	-2.543*** (0.455)	1.435*** (0.268)	-0.286* (0.170)	2.065*** (0.290)	0.407 (0.262)
$TF\ KOR - COL^{k}_{ijt}$	0.536*** (0.159)	-0.272 (0.166)	0.055 (0.298)	-0.172 (0.229)	-0.080 (0.158)	0.070 (0.088)	-0.657*** (0.137)	0.401 (0.247)
$IMP\ COL - LAC^{k}_{ijt}$	-0.002 (0.156)	-0.441*** (0.147)	-0.346 (0.242)	-0.654*** (0.245)	-0.228 (0.166)	-0.188 (0.196)	0.266 (0.408)	-0.199 (0.145)
$IMP\ COL - ESEA^{k}_{ijt}$	-0.081 (0.094)	0.312*** (0.121)	-0.338*** (0.096)	-0.113 (0.124)	0.140 (0.147)	0.367*** (0.072)	0.193 (0.171)	0.294*** (0.106)
$IMP\ KOR - LAC^{k}_{ijt}$	0.219* (0.114)	-0.577** (0.259)	0.244 (0.370)	0.123 (0.766)	0.422* (0.219)	0.613*** (0.108)	-0.342 (0.521)	-0.172 (0.231)
$IMP\ KOR - ESEA^{k}_{ijt}$	0.068 (0.163)	-0.149 (0.100)	-0.594*** (0.157)	-0.094 (0.275)	0.003 (0.115)	0.201*** (0.077)	-0.684*** (0.094)	-0.109 (0.246)
$EXP\ COL - LAC^{k}_{ijt}$	-0.210 (0.242)	-0.401** (0.201)	-0.142 (0.478)	-2.351*** (0.410)	0.684** (0.279)	0.058 (0.175)	0.197 (0.322)	-0.453** (0.197)
$EXP\ COL - ESEA^{k}_{ijt}$	-0.176 (0.290)	0.367 (0.233)	0.726* (0.404)	-0.490 (0.516)	0.671** (0.305)	1.010** (0.468)	0.136 (0.360)	-0.019 (0.414)
$EXP\ KOR - LAC^{k}_{ijt}$	0.189 (0.247)	-0.283 (0.219)	0.274 (0.410)	-0.279 (0.393)	-0.010 (0.149)	-0.045 (0.076)	-0.236* (0.125)	-0.382 (0.312)
$EXP\ KOR - ESEA^{k}_{ijt}$	-0.114 (0.219)	-0.154 (0.199)	-0.138 (0.427)	0.429 (0.264)	-0.273*** (0.103)	0.475*** (0.119)	-0.590** (0.242)	-0.185 (0.245)
Constant	12.607*** (0.123)	13.437*** (0.110)	12.670*** (0.286)	13.867*** (0.204)	13.933*** (0.109)	15.792*** (0.135)	14.495*** (0.203)	14.005*** (0.180)
Observations	100,991	103,917	81,525	91,369	101,472	111,875	91,035	104,985
Clusters	7,222	7,406	6,451	6,826	7,292	7,649	6,948	7,409
Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (9)-(16) present the results using a Poisson Pseudo-Maximum Likelihood (PPML) estimator based on multiplicative form for the analysis sample (100 countries between 2005-2022) in CEPII's BACI Database. Sector-Groups (k) considered were: (9) Wood, (10) Textiles/Clothing, (11) Footwear, (12) Stone/Glass, (13) Metals, (14) E-Machinery, (15) Transportation, and (16) Miscellaneous. Others include two control variables for time-varying drivers of bilateral trade flows: FTA_{ijt} and WTO_{ijt} , three-way fixed effects, i.e., exporter- time, importer-time, and exporter-importer. Standard errors clustered by country-pair in parenthesis. *p<0.10, **p<0.05, ***p<0.01.



Likewise, *TF KOR-COL* coefficients for (6) Chemicals and (15) Transportation are statistically significant, yet they show a decrease in trade flows from Korea to Colombia by 41% and 48%, respectively. Despite the immediate tariff cuts on heavy industry goods and capital equipment, (13) Metals and (14) E-Machinery show minimal or no increase in trade flows. Besides, the decline in vehicle sales and auto parts is largely due to the 2014-2015 oil price crash, which led to a real COP depreciation and negatively impacted Colombian imports (Melo et al., 2020), particularly from Asian exporters like Korea.

Trade Diversion Figures A4 and A5 depict the strict trade diversion effects for each Sector-Group, especially for regions with greater trading inertia. Negative and statistically significant coefficients for *IMP COL-LAC* in (6) Chemicals, (10) Textiles/Clothing, and (12) Stone/Glass indicates a decrease in imports from *LAC*. Until 2012, imports from South America grew steadily, but the Colombia-US FTA likely redirected focus. Following the 2014 commodity price crisis, imports of fabrics, marble, and petrochemical products dropped and remained low until, at least, 2021 (see Figure A4a).

Similarly, negative coefficients for *IMP KOR-ESEA* in (1) Animal, (11) Footwear, and (15) Transportation suggest a decrease in imports from *ESEA* (see Figure A5b). The high trend in imports of electronics, machinery, and chemicals continued until 2008 when it dropped due to the financial crisis, but recovered by 2010. This reduction is attributed to transitions in consumer preferences, increased domestic production capabilities, and shifting trade policies from China (Kim, 2021).

Insights This paper finds many economically and statistically significant effects that are literature-consistent since the FTA has eased sector-differentiated trade creation based on each country's specialization, aligning with $\mathbb{H}_1$. Still, so far, the treaty has not impacted all sectors involved in the negotiation, particularly for Korea.

One must acknowledge that the dynamics within each industry are shaped not only under the FTA tariff and non-tariff measures but also by broader international factors like political or economic phenomena. For instance, while customs cuts were intended to boost Colombian exports of food or clothing and Korean exports of plastics and vehicles, this has not occurred yet. The reasons are varied, as each good has its own story, particularly significant given the differences in size and scope among the industries.

Thus, while the aggregate results discussed above remain robust, these Sector-Group analyses -valuable in a qualitative sense- are limited in capturing the full range of drivers influencing trade beyond the immediate effects of the agreement. External forces may either counterbalance or amplify the impact of trade liberalization.

Synthetic Counterfactuals Figure D2 shows actual and synthetic counterfactual trade flow for the treated units by Sector-Group. Synthetic COL-KOR and KOR-COL display little blurriness in the data fitting on all pre-treatment periods. Although not all of them line up perfectly in terms of magnitude and statistical significance with the gravity model, there exists empirical and visual evidence suggesting that the observed effects are an outcome of the reduction of tariffs, or at least highly related to it.

Trade Creation While Colombia appears to be the major beneficiary of the FTA, the impact on Korea is mixed, with lower gains and some industries showing negative trade dynamics. Colombia's highest gains come from (5) Fuels, peaking in 2018 with a net gap effect of \$328 million. This result is not explained by the trade policy, as they were not included in the agreement. Instead, it likely reflects the leveraging of bilateral relations to replace energy imports from other countries.

Between 2016-2017, Colombian exports to Korea of (1) Animal, (6) Chemicals, (13) Metals, and (15) Transportation improved the most but rapidly declined in 2018-2019. After that, (7) Plastic/Rubber saw a significant rise in trade flows but also diminished in the next two years. Lastly, for (8) Hides/Skins, both the observed and synthetic trade flows remained close throughout the series -with no effect- while facing a downward trend. Only (2) Vegetable and (9) Wood were able to sustain gains up to 2022.

For Korea, its highest loss is attributed to (15) Transportation with a net gap effect of -\$205 million. The drop in sales can also be attributed to external factors like the rise of tariff-free vehicle imports from Mexico and MERCOSUR (see [Statista](#)). However, exports to Colombia of (1) Animal, (3) Foodstuffs, and (4) Minerals experienced positive effects in the early years after the FTA's inception; yet, they dissipated rapidly over time, with some observed trade flows even falling below the synthetic counterfactuals.

Insights These individual results suggest that the positive trade creation effect for Colombia, contrasted with the negative one for Korea, may stem from differences in market saturation levels and export growth potential. Colombia is leveraging its flexible industrial capacity and untapped sectors to meet rising demand, particularly in Asian markets, while Korean exports are likely constrained by diminishing returns in more productive sectors. Despite the immediate tariff reductions/eliminations, Korea struggles to generate significant trade growth. Moreover, the higher relative prices of Korean goods, especially in capital-intensive sectors like automotive and electronics, make them less competitive compared to alternative suppliers within the *LAC* region, particularly during periods of exchange rate fluctuations and economic downturns.

4.2 Multidimensional Distances

4.2.1 Geography: Crossing The Pacific

One salient finding in the gravity model literature, when computing bilateral trade costs, is that geographical distance obstruct trade. This paper is no exception. Columns (1), (2), (3), and (6) reported in Table 2 reflect this, with the negative and positive coefficients of $\ln(H\text{-Distance})$ and *Border* -which appears to ease it-, respectively. Geographically speaking, Colombia ranks 11th among the countries with which Korea trades, and in turn, they rank 13th among the countries with which Colombia trades in Gravity and BACI Databases. Thus, since they do not share a terrestrial boundary and for simple effect of gravity forces, a small trade exchange between them is expected.



At least 15,000 km disconnect Buenaventura, Colombia, from Busan, Korea, the two most important distribution sites (see [Google Earth](#)). Crossing the world's largest ocean is a major logistical challenge for successful goods exchange. [ProColombia](#) has identified various transport options to Korea, comprising 34 transport companies, with 13 air routes and 46 maritime. Although there are no direct services available in either mode, some airlines offer routes with daily frequencies and low connection times (see [Google Flights](#)), as well as shipping companies like Maersk or MSC that commit to delivering in 23-29 days, once reshipment is completed at logistics hubs in Panama or Mexico.

Distance is a physical barrier to trade ([Ghazalian, 2015](#); [Wu et al., 2020](#)) since exporters must incur *ad valorem* tariff rates for entire units of goods to arrive at their destination. [Chaney \(2018\)](#) argues that this difference is very likely to be influenced by transportation costs, which are correlated with linear distance as countries tend to exchange more with closer countries, because of the reduction in average distances ([Carrere and Schiff, 2004](#)) and commercial frictions. In this regard, Colombia has reduced its average trade distance by 24% between 1962 and 2020 thanks to infrastructure investments. Still, the underdeveloped secondary and tertiary roads in rural areas have constrained the transport of goods to ports ([Oxford-Analytica, 2020](#)), thus limiting trade potential.

4.2.2 Culture: East and West

Under Spanish rule for over 300 years, Colombia developed an economy based on resource extraction and control, leading to persistent poverty and inequality. Korea, occupied by Japan from 1910-1945, experienced both modernization and industrialization, alongside cultural exploitation. However, its pre-existing religious and social structures fostered a national culture of discipline and innovation despite the occupation.

These colonial inheritances could have impacted current relations by influencing the ways to conduct business. Besides, the need for constant translation and the potential loss of important nuances in contracts are an unobserved trade barrier. Errors in interpreting negotiations due to the absence of a minimum reservoir of trust, necessary to initiate and complete deals, also delay processes and increase costs ([Tadesse and White, 2010](#)).

Estimates reported in Table 2 in columns (1), (2), (3), and (6), once again, capture the impact of all the above via proxy variables such as *Colony*, *Religion*, and *Language* on trade flows. As shown in column (6), all three variables display economic and statistical significance. This finding is literature-consistent since former/current colonies and their colonizers often share consumer preferences, common language, business practices, and culture which lowers transaction costs and eases trade ([Berthou and Ehrhart, 2017](#)).

To date, there have been very few initiatives to bring the countries closer culturally beyond honorary attendances at International Fairs or celebrations of the establishment of diplomatic relations that have received some media coverage.¹⁷ Yet, it is still necessary to boost attraction to culture to enhance goods exchange between them.

¹⁷See, for instance, [Revista Portafolio](#), [Cancillería](#) or [Valle del Cauca - Gobernación](#) news report.

5 Robustness Checks

To assess the robustness of the results, this paper relaxes the restrictions on the number of countries and the study period imposed by the gravity model. Additionally, both spatial and temporal placebo tests are conducted on the synthetic counterfactuals related to the trade creation effects. This battery of tests helps determine whether the results are due to random chance or if they are most likely a true effect of the trade policy.

5.1 Gravity Model of Trade: Country Count and Time Frame

A common critique of the gravity model results for assessing economic integration impacts on trade flows is that they are mainly driven by the country selection and/or the periods used in the assessment. Table E1 reports complementary estimates of equation (3.2.5) under both the asymmetric and symmetric approaches using a PPML estimator, and employing three-way fixed effects. Columns (1)-(4) show the results using the full sample (149 countries). Columns (1) and (2) leverage a first alternative time frame (1995-2021), while columns (3) and (4) leverage a second alternative time frame (2010-2021). Columns (5) and (6) use the analysis sample but subtract (5) Fuels and (15) Transportation trade flows from Colombia and Korea, respectively.

Across all symmetric specifications varying the country count and time frame, the *FTA COL-KOR* coefficient remains statistically insignificant. Thus, a null average treatment effect due to the FTA holds. Furthermore, *TF COL-KOR* and *TF KOR-COL* coefficients remain consistent with those presented in Table 2. The majority are within one standard deviation and suggest an average increase in trade flows of 166% for Colombia, but a decrease of 27% for Korea. Estimates from Table E1 also enjoy high statistical power due to the inclusion of 46 additional countries and an extension of +10 years in the analysis. These sample sizes are significantly larger than that of the primary estimates, ensuring desirable properties like consistency and reduced standard errors.

After excluding traditional exports, the *TF COL-KOR* coefficient maintains direction and statistical significance, but is almost 40% smaller, suggesting only an 81% trade flow increase. This indicates that Colombia is still benefiting from a broad range of industries, featuring the FTA's impact beyond its main export product. Yet, this is not the case for Korea as the *TF KOR-COL* coefficient does not possess statistical significance. Following the Sector-Group estimates, one could think that the drop in vehicle sales is dragging the aggregate effect of the FTA, making it appear negative when, in reality, it is neutral.

On the flip side, columns (1)-(6) show no statistically significant negative coefficients for strict trade diversion effects neither from *LAC* nor from *ESEA*. Only when considering the relaxed version columns (5) and (6) display a slight reduction in Korea's exports to *LAC* by 17%. This result further supports $\mathbb{H}_2$ indicating that no import shift is occurring from non-FTA partners in regions where Colombia and Korea typically trade.



5.2 Synthetic Counterfactuals: Spatial and Temporal Placebos

Spatial Placebo As is standard in the SCM literature (Abadie et al., 2015; Abadie, 2021), each unit in the donor pool is taken and, falsely, presumed to have implemented an economic integration in 2016. The difference between the observed donor pool units and their synthetic counterfactual after 2016 is plotted. This exercise is repeated for each country-pair within the third-party regions to create a distribution of “false” treatment effects. If the effect presented in Figure 2 differs from mere chance, then the net gap should sit in its head (tail) for COL-KOR (KOR-COL) estimates.

To further refine the donor pool, only units with synthetic trade flows that deviate by no more than 25% from actual trade flows in at least half of the pre-treatment periods are selected. The idea lies in excluding units that had significant trade creation effects before the FTA but in reality, were not treated, as they could contaminate the observed effects’ magnitude and statistical significance. However, it can reduce the sample size, potentially affecting the estimators’ desired properties. Also, it increases the risk of overfitting, which limits the external validity of the results. On average, this strict selection criterion shall not eliminate relevant units since it was already accomplished in Subsection 3.3.

Figure E1 shows the net gaps between the actual and synthetic counterfactual trade flows for each placebo country-pair inside the constrained donor pool. For COL-KOR, the observed trade flow line sits well above the placebos for the periods after 2015. By 2018, the divergence has grown substantial enough that scarcely any false treatment effects are able to replicate it. One can see it peaking its trade creation value of \$349 million among all in 2020 (see Figure E1a). Conversely, KOR-COL exhibits a severe underperformance compared to the placebos, especially from 2017 onward, with the gap widening sufficiently by 2018 to reach its lowest value of -\$673 million in 2019 (see Figure E1b).

Table E2 shows the standardized *p-values* associated with the causal effects of the trade policy for all post-treatment periods. For COL-KOR and KOR-COL trade creation estimates, during the first two years following the FTA’s inception, the associated *p-values* do not fall within the 10% significance band, reflecting a period of policy adjustment. From 2019 onwards, the *p-values* primarily hover around the 90% and 94% confidence levels, indicating that the proportion of effects observed with greater magnitude between 2019-2021 is likely small. This lends robustness to the results, as the treatment effect for the period is not only economically, but also statistically significant.

Temporal Placebo It consists of assigning a false treatment date before the actual one to verify if the results obtained are, for instance, due to globalization effects or unrelated treatment factors. If the analysis with the false date shows effects similar to those of the actual treatment, it may indicate that the original results are not caused by the trade policy but by other trends or events. Hence, this paper back-sets the treatment three years prior to the official signing of the FTA. Figure E2 shows actual and synthetic counterfactual trade flows for both countries using 2010 as the treatment year.

In Figure 2a, COL-KOR synthetic trade flow line exhibits a discrepancy compared to the observed prior to the actual treatment year. It significantly underestimates the latter between 2013 and 2014, but then stabilizes back to the upward trend by mid- 2015. This is why one notices a sharp hill in 2014 (see Figure E2c), as it coincides with the FTA signature, with a one-year delay. However, after 2015, there is a positive trend in the increase of trade flows that is sustained until 2021. For all post-treatment periods, the net gap is positive with the monetary value of trade creation being over \$300 million by 2020. This also supports the validity of the original estimates.

The case for KOR-COL is more straightforward as the synthetic trade flow line closely follows the observed from 2010-2015 (see Figure E2b). Figure E2d displays a net gap that fluctuates very close to zero for this period. Once the agreement comes into effect, there is a notable decrease in trade flows and its negative trend does not seem to correct over time. While this result proves directionality robustness, it overestimates the loss in trade creation value since it is greater (in absolute value) than what is displayed in Figure 2d. Thus, one must be cautious interpreting this finding, as the inferences made on the gravity model and the synthetic counterfactual estimates may falter.

6 Public Policy Implications

The results of the empirical exercise suggest that the utilization of the FTA has been rather uneven. This stresses the need to determine what is missing to ensure the treaty's success. The present Section summarizes progress made in closing the gaps to fully capitalize on the trade policy while also presenting two concise proposals to enhance its effectiveness and deliver tangible short-term benefits for both parties.

Law 1868 of 2017 mandates the submitting of the annual report on the development, progress, and consolidation of trade agreements ratified by Colombia. This report outlines the achievements and challenges in terms of economic integration. According to MinCIT (2024), the Colombia-Korea FTA has reached significant milestones, including:

- (2018) Negotiation, approval, and exchange between the parties of the Terms of Reference for the Committee on SPS Measures in both administrative grounds.
- (2020) Endorsement of a cooperation memorandum with the Korea Institute for Industrial Economics and Trade to promote research, knowledge sharing, and the exchange of experiences and activities related to secondary-sector economics.
- (2021) Creation of the *Consejo Empresarial Colombia-Korea* by the *Cámara de Comercio de Bogotá* and the Korea Chamber of Commerce and Industry.
- (2023) Improvement of the understanding of the certificate of origin guidelines in English, Spanish, and Korean versions by Korea's Ministry of Trade, Industry, and Energy.
- (2024) Instruction for exporters to self-certify using a new format agreed upon in Appendix 3-C of the document, instead of through government entities.



While it is true that thanks to constant dialogue and synergy, progress has been made toward achieving comprehensive regulatory alignment, promoting the agreement, and reducing non-tariff barriers, these efforts have often been lengthy and highly bureaucratic. Hence, to revive trade flows, this paper suggests the following policies:

Digital Compliance It addresses the persistent obstacles exporters and importers face in abiding by international trade regulations. The policy focuses on developing a digital platform designed to centralize compliance documentation, certification processes (e.g., phytosanitary or origin), and other trade-related requirements. This would remove the need for intermediaries, such as translators or Chambers of Commerce, and reduce procedural delays caused by errors in form completion or misplaced paperwork.

The platform could be AI-powered to scan products, identify needed compliance, and automatically pre-filling forms. The tool, by implementing machine learning methods, refines its precision over time. This initiative would primarily impact products that require detailed reviews, such as organic compounds, petrochemical derivatives, and flammable goods, which represent a major portion of trade between the countries.

In addition, the platform can offer real-time updates on regulatory changes and tariff elimination schedules. This would enable non-expert traders -those unfamiliar with the treaty specifics- to stay informed about market conditions without incurring the costs of consultancy services. Finally, to ensure rapid implementation and immediate impact, the platform could be built on existing digital infrastructure, in collaboration with private sector technology firms experienced in e-commerce and legal systems.

SME Accelerator An SME accelerator program would increase the inclusion of new businesses in the market, specifically designed for companies exporting or importing for the first time. The policy focuses on educating SMEs about Colombian and Korean trade demand, consumer preferences, product standards, and logistics without relying on big companies that impose large entry fees. The program could offer practical workshops on using digital tools for market research, certification, and e-commerce, allowing SMEs to bypass traditional facilitators and engage directly with buyers and sellers.

The accelerator would provide access to low-cost or subsidized trade fairs and match-making events that promote the advantages and opportunities offered by the agreement. In particular, this would include virtual product showcases, cutting out the need for in-person attendance. This impacts two fronts: i) it allows SMEs to create strategic links with buyers and investors, increasing trust, and ii) it enables SMEs to test their products in international markets with lower risk, reducing the frequency of failed deals.

To boot, the program could offer customized export loans or grants at accessible interest rates, along with post-trade-entry support and training, such as ongoing consultancy and troubleshooting services. By concentrating on reducing informational and financial barriers, the policy fosters sustainable business relationships and enhances the capacity of SMEs to achieve long-term growth and success in international markets.

7 Conclusions

This paper sheds light on trade-related effects of the Colombia-Korea FTA. By combining a gravity model of trade with synthetic control methods, it empirically assesses its impact on bilateral trade flows. The estimation results reveal asymmetric trade creation effects. While Colombia exhibits a significant increase in exports to Korea, Korea sees a decline in exports to Colombia. In parallel, there is no evidence of strict trade diversion effects for any country as imports from non-*LAC* and non-*ESEA* countries were unaltered.

These findings provide insights into how two countries, despite a tariff liberalization agreement, can experience divergent outcomes that do not align with traditional trade literature. Two mechanisms may be at play: first, extensive market saturation limits export growth opportunities; second, established trade relationships preserve existing trade patterns, indicating that the perceived benefits of shifting importers may be minimal. Future expansion of this work can test these mechanisms by analyzing industry-specific data on demand growth and production capacity, along with logistical metrics, regional integrations, and comparative advantages within these trade hubs.

This paper, still, has inherent limitations. They stem from the relatively short analysis time frame, which could bias the assessment of its long-term effects. The sample period may not be enough to capture the full impact on trade, including structural adjustments and specialization shifts. Besides, focusing on aggregate and sectoral trade flows, although providing a broad overview, conceivably misses macro and micro-level impacts, changes in supplier behavior or the distributional effects of the FTA on different groups.

The Colombia-Korea FTA has the potential to either support the transition to a more intra-industrial, complementary relationship between the two economies or, alternatively, keep the current agro/tech-based economic structure. The direction it takes will largely depend on the ability to recognize and address the importance of dropping remaining trade barriers and ensuring a level playing field across all sectors covered by the FTA. This requires fostering an environment that encourages foreign direct investment, overcoming the various dimensions of distance, and implementing public policies that enhance competitive market access while promoting sustainable economic integration.

Conflict of Interest Statement

The author declares that there was no conflict of interest at the time of writing this paper.



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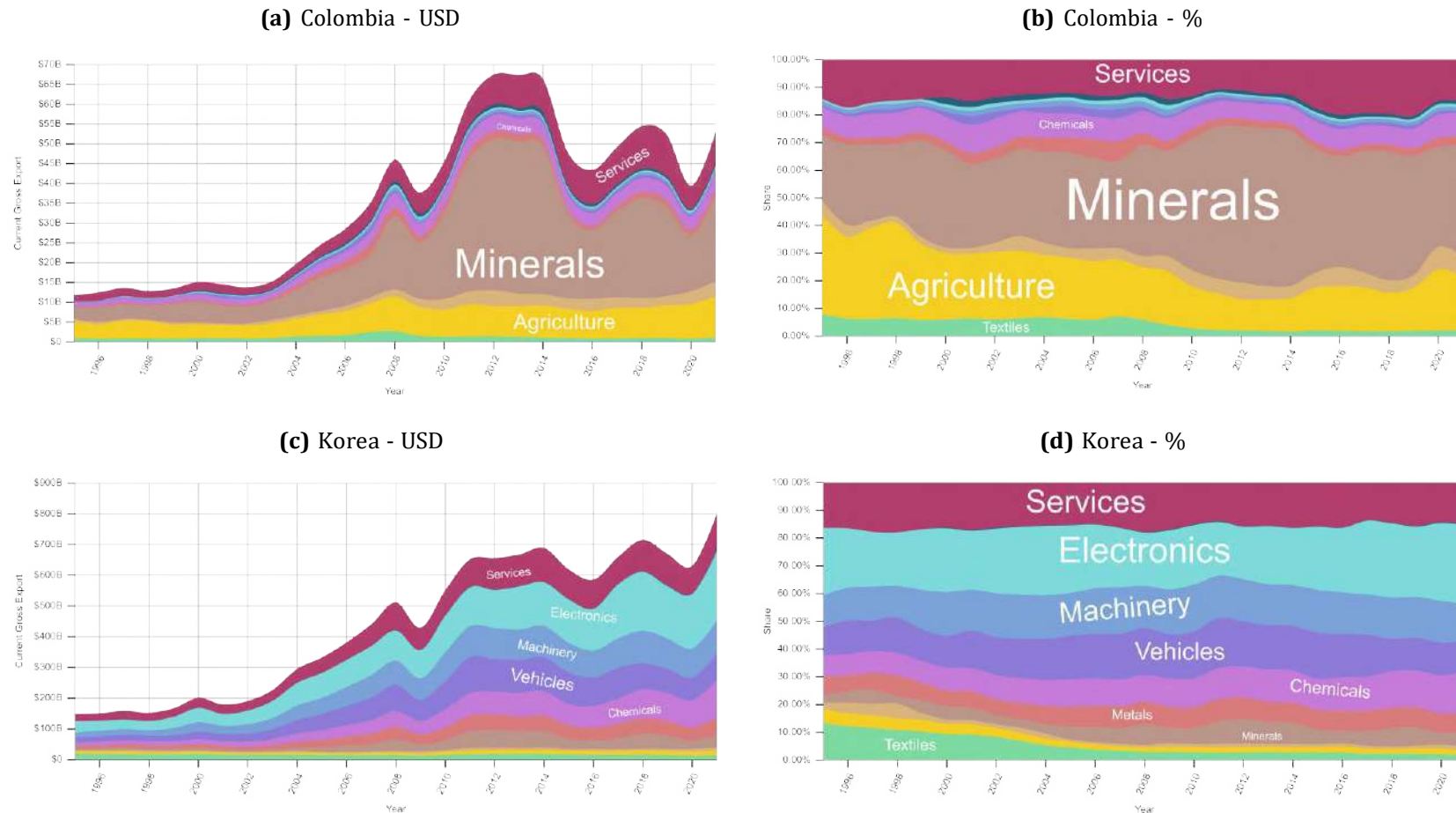
Appendix

Table of Contents	Page
Appendix A: Additional Figures	A1
A1 Colombia and Korea Global Market Share	
A2 Colombia and Korea Main World Export and Import Partners	
A3 Trade Flows between Colombia and Korea by HS2 Chapters	
A4 Colombian Imports (Exports) from (to) South America and East Asia	
A5 Korean Imports (Exports) from (to) South America and East Asia	
Appendix B: Additional Tables	A6
B1 Colombia's Current Economic Integration's	
B2 Korea's Current Economic Integration's	
B3 Colombia and Korea Macroeconomic Descriptors	
B4 Negotiated Concession Levels by Product	
B5 Summary Statistics - CEPII Gravity Database	
B6 Summary Statistics - CEPII BACI Database	
B7 Mean Differences by Regions	
Appendix C: Structural Gravity System	A12
C1 Variables and Parameters***	
Appendix D: Synthetic Control Method	A13
D1 Potential Donor Pool Units Identification*	
D1 Predictor Balance Prior to 2016 for COL-KOR and KOR-COL Estimates**	
D2 Synthetic Counterfactual Estimates by Sector-Group, Trade Creation*	
Appendix E: Robustness Checks	A21
E1 Gravity Model Complementary Estimates**	
E1 Spatial Placebo Test for COL-KOR and KOR-COL Estimates, Trade Creation*	
E2 Standardized Probabilistic Values for Estimated Periods, Trade Creation**	
E2 Temporal Placebo Test for COL-KOR and KOR-COL Estimates, Trade Creation*	

Notes: *Figure, **Table, ***Descriptive. All objects contain a hyperlink ([\[Return to text\]](#)) that allows readers to return to the line where they are initially referenced.

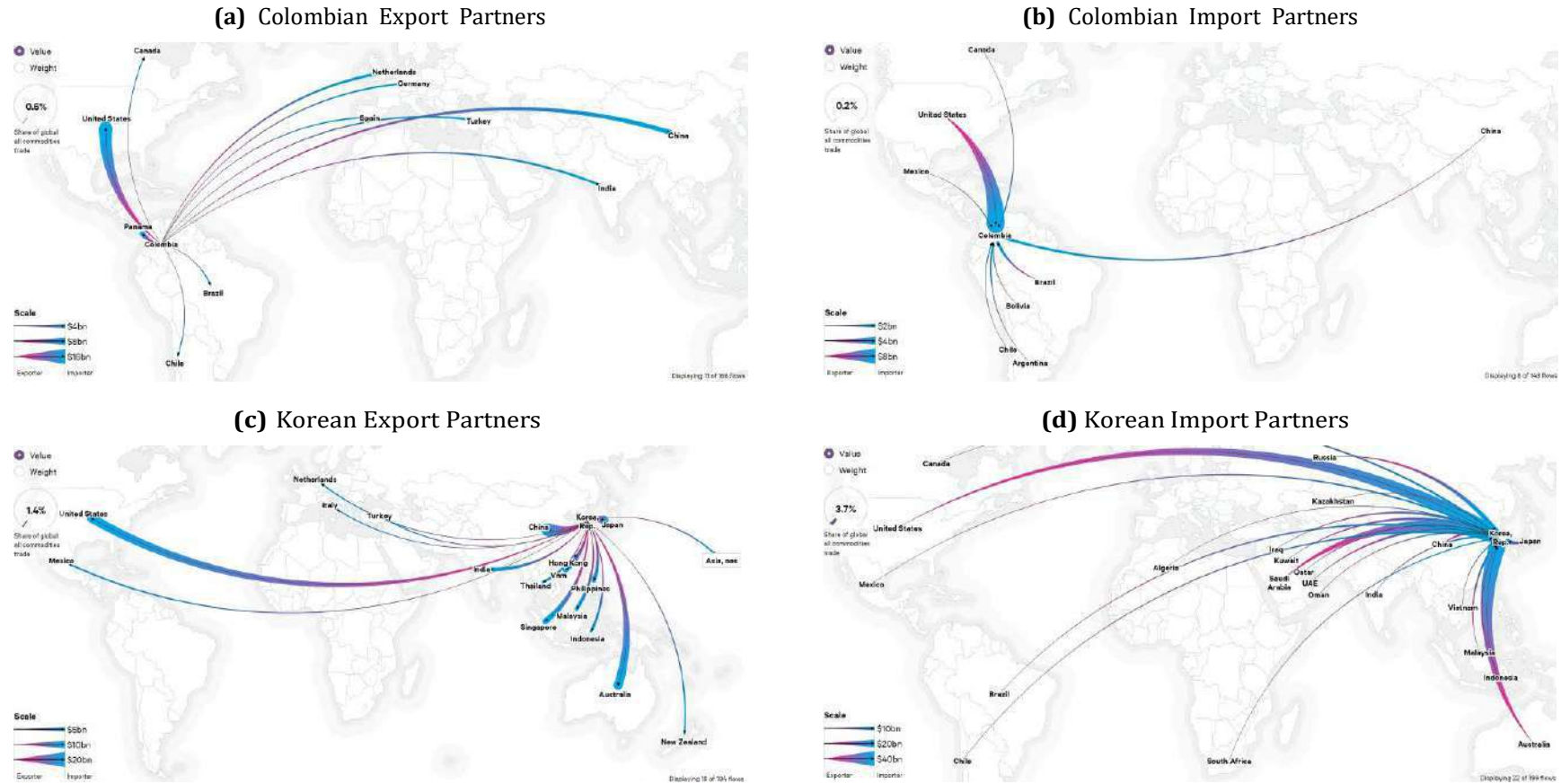
A Additional Figures

Figure A1: Colombia and Korea Global Market Share



Notes: Panels (a) and (c) plot the current gross exports value in USD (billions), while Panels (b) and (d) plot the market share (%) of Colombia and Korea, respectively, using the 1-digit Harmonized System (HS1) between 1995-2021. Data coming from [The Atlas of Economic Complexity](#). [\[Return to text\]](#)

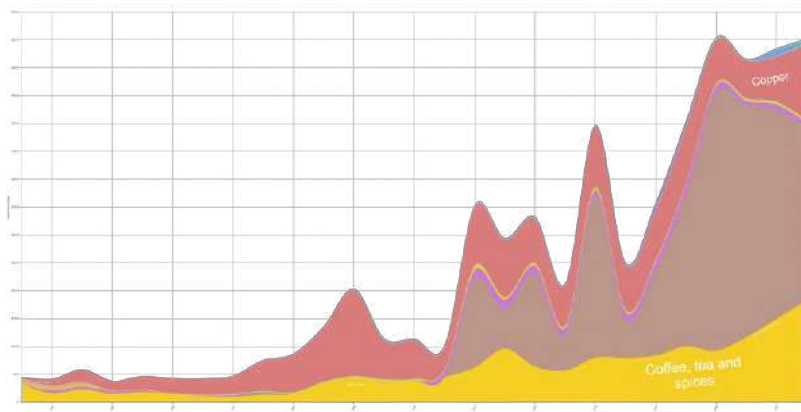
Figure A2: Colombia and Korea Main World Export and Import Partners



Notes: Panels (a) and (c) plot the main export partners, while Panels (b) and (d) plot the main import partners of Colombia and Korea, respectively, in 2021. Scale conventions in left bottom corner of each Panel. Data coming from [ResourceTrade.Earth](#). [\[Return to text\]](#)

Figure A3: Trade Flows between Colombia and Korea by HS2 Chapters

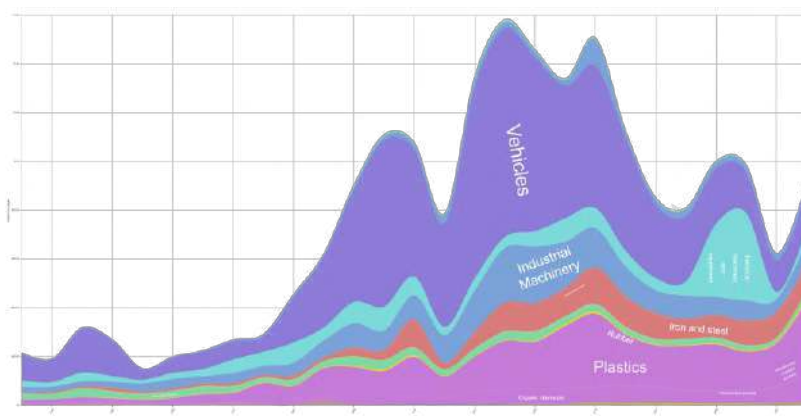
(a) Colombia to Korea - USD



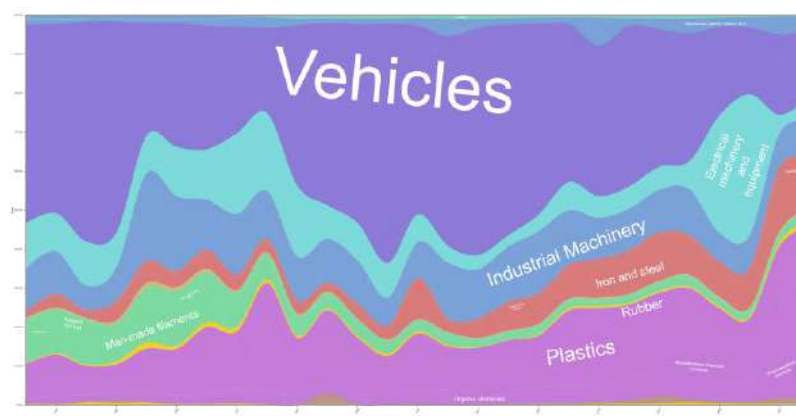
(b) Colombia to Korea - %



(c) Korea to Colombia - USD



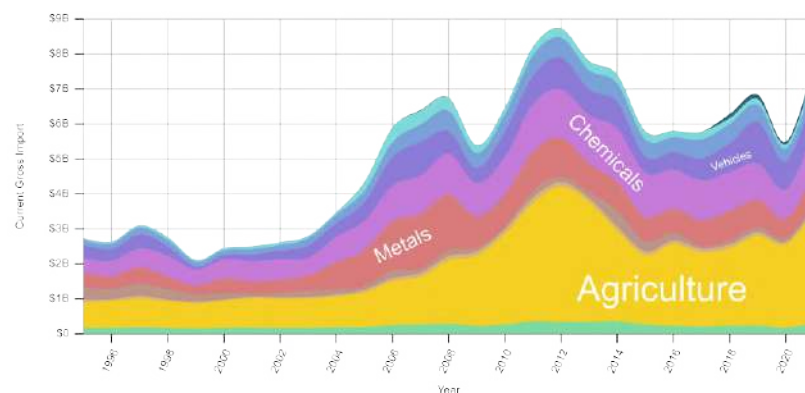
(d) Korea to Colombia - %



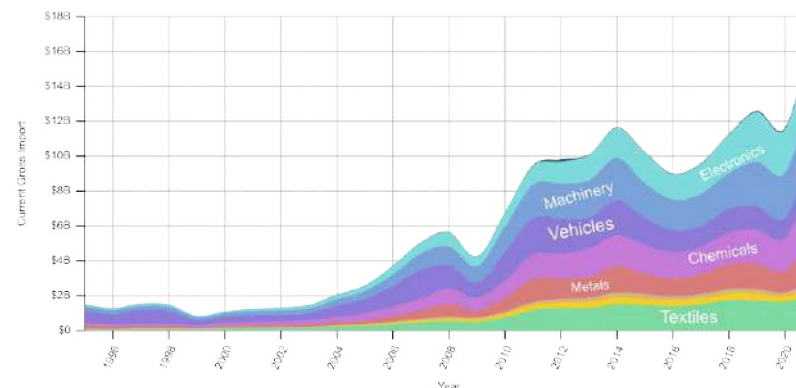
Notes: Panels (a) and (c) plot the trade flows value in USD (billions), while Panels (b) and (d) plot the market share (%) between Colombia and Korea, respectively, using the 2-digit Harmonized System (HS2) between 1995-2021. Data coming from [The Atlas of Economic Complexity](#). [\[Return to text\]](#)

Figure A4: Colombian Imports (Exports) from (to) South America and East Asia

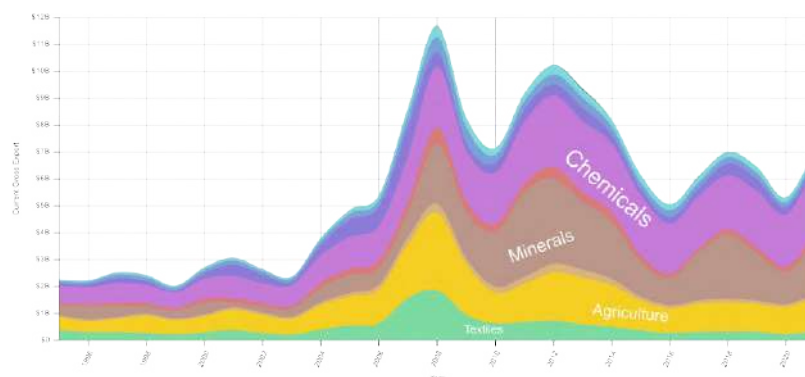
(a) Imports from South America



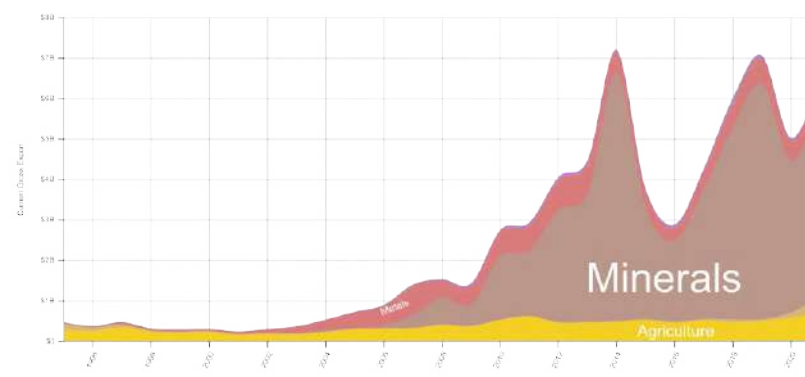
(b) Imports from East Asia



(c) Exports to South America



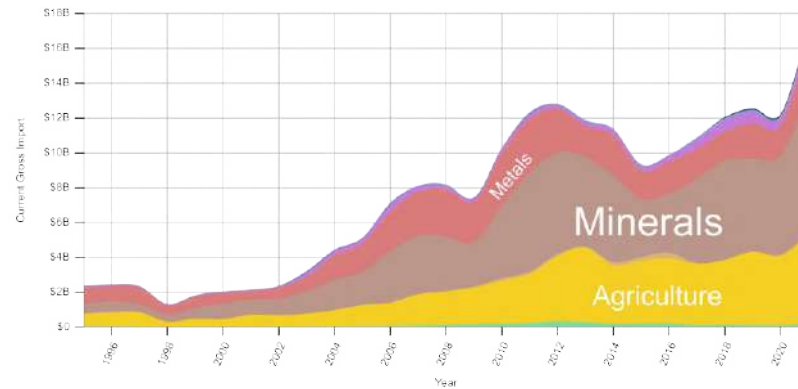
(d) Exports to East Asia



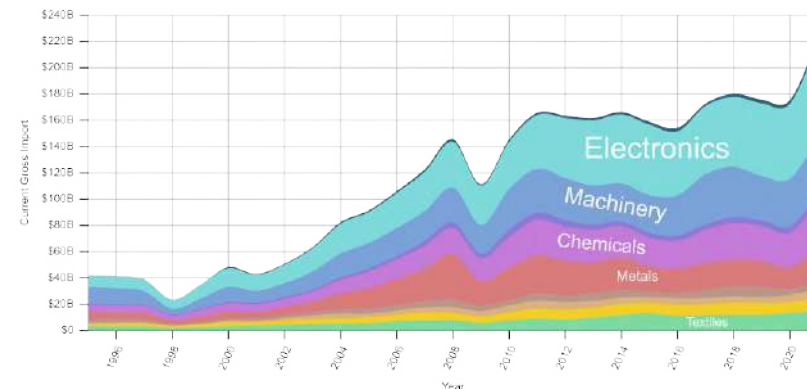
Notes: Panels (a) and (b) plot the current gross imports to Colombia, while Panels (c) and (d) plot the current gross exports from Colombia in USD (billions) from (to) America, America, and East Asia using the 1-digit Harmonized System (HS1) between 1995-2021. Data coming from [The Atlas of Economic Complexity](#). [\[Return to text\]](#)

Figure A5: Korean Imports (Exports) from (to) South America and East Asia

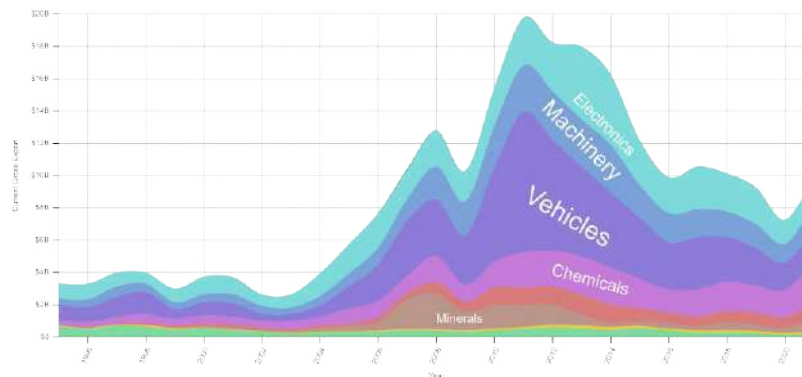
(a) Imports from South America



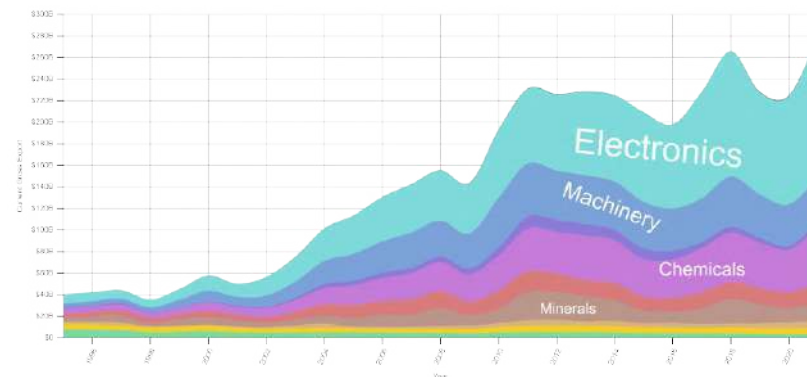
(b) Imports from East Asia



(c) Exports to South America



(d) Exports to East Asia



Notes: Panels (a) and (b) plot the current gross imports to Korea, while Panels (c) and (d) plot the current gross exports from Korea in USD (billions) from (to) America, Asia, South America, and East Asia using the 1-digit Harmonized System (HS1) between 1995-2021. Data coming from [The Atlas of Economic Complexity](#). [\[Return to text\]](#)

B Additional Tables

Table B1: Colombia's Current Economic Integration's

Partner	Signature	Effective Since	Scope
<i>Asociación Latinoamericana de Integración</i>	August 1980	March 1981	P-SA
<i>Comunidad Andina</i>	May 1987	May 1988	CU
<i>Comunidad del Caribe</i>	July 1994	January 1995	P-SA
Mexico	January 1994	January 1995	FTA
Cuba	September 2000	July 2001	ECA
<i>Mercado Común del Sur</i> (BRA, ARG, URY)	October 2004	February 2005	ECA
<i>Mercado Común del Sur</i> (PRY)	October 2004	April 2005	ECA
Chile	November 2006	May 2009	FTA
<i>Triángulo del Norte</i> (GTM)	August 2007	November 2009	FTA
<i>Triángulo del Norte</i> (SLV)	August 2007	February 2010	FTA
<i>Triángulo del Norte</i> (HND)	August 2007	March 2010	FTA
European Free Trade Association (LIE, CHE)	November 2008	July 2011	FTA
United States	November 2006	May 2012	FTA
Venezuela	November 2011	October 2012	P-SA
European Union	June 2012	August 2013	FTA
European Free Trade Association (ISL, NOR)	November 2008	September 2014	FTA
Korea	February 2013	July 2016	FTA
Costa Rica	May 2013	August 2016	P-SA
Israel	September 2013	August 2020	FTA

Notes: ISO 3166-1 alpha-3 country codes are: BRA, Brazil; ARG, Argentina; URY, Uruguay; PRY, Paraguay; GTM, Guatemala; SLV, El Salvador; HND, Honduras; LIE, Liechtenstein; CHE, Switzerland; ISL, Island, and NOR, Norway. Scope conventions are: P-SA, Partial-Scope Agreement; CU, Customs Union; FTA, Free Trade Agreement, and ECA, Economic Complementation Agreement. Data coming from DANE booklets released in 2023. [\[Return to text\]](#)

Table B2: Korea's Current Economic Integration's

Partner	Signature	Effective Since	Scope
Protocol Relating to Trade Negotiations	December 1971	February 1973	P-SA
Asia-Pacific Trade Agreement	July 1975	June 1976	FTA
Chile	February 2003	April 2004	FTA
Singapore	August 2005	March 2006	FTA
European Free Trade Association	December 2005	September 2006	FTA
Association of Southeast Asian Nations	August 2006	January 2010	P-SA
India	August 2009	January 2010	FTA
European Union	October 2010	July 2011	FTA
Peru	March 2011	August 2011	FTA
United States	June 2007	March 2012	FTA
Turkey	August 2012	May 2013	FTA
Australia	April 2014	December 2014	FTA
Canada	September 2014	January 2015	FTA
China	June 2015	December 2015	FTA
New Zealand	March 2015	December 2015	FTA
Vietnam	May 2015	December 2015	FTA
Colombia	February 2013	July 2016	FTA
Central America	February 2018	October 2019	FTA
United Kingdom	August 2019	January 2021	FTA
Regional Comprehensive Economic Partnership	November 2020	January 2022	FTA
Cambodia	October 2021	December 2022	FTA
Indonesia	December 2020	January 2023	FTA

Notes: Scope conventions are: P-SA, Partial-Scope Agreement, and FTA, Free Trade Agreement. Data coming from DANE booklets released in 2023. [\[Return to text\]](#)

Table B3: Colombia and Korea Macroeconomic Descriptors

Variable	Unit	Colombia	Korea
Capital	-	Bogota	Seoul
Surface	km ²	1,141,748	100,210
Population	Inhabitants	51,682,692	51,628,117
Exchange Rate	\$/USD	4,055 COP	1,291 KRW
GDP current	USD	343,683	1,673,924
Foreign Direct Investment	USD	16,868	17,996
Exports	USD	56,910	683,550
Imports	USD	77,413	731,361
GDP per capita	USD	6,624	32,422
GDP growth rate	%	7.51	2.62
Exports/GDP current	%	16.55	40.83
Imports/GDP current	%	22.52	43.69
UTC	hours	-5	+9

Notes: COP stands for Colombian Peso, KRW for Korean Republic Won, and UTC for Universal Coordinated Time. GDP current, Foreign Direct Investment, Exports and Imports are measured in millions. GDP growth rate is computed by comparing it with 2021. Values below 1,000 are displayed with two decimal places, while those above 1,000 are rounded to the nearest unit. Data coming from DANE booklets released in 2022. [\[Return to text\]](#)

Table B4: Negotiated Concession Levels by Product

Concession period	Colombia		Korea	
	N° of products	%	N° of products	%
Immediate	9,797	82.38	4,390	60.64
Within 5 years	928	7.89	1,579	21.82
Within 10 years	694	5.84	1034	14.27
After 10 years	304	2.56	184	2.54
Contingent	5	0.04	6	0.08
Excluded	153	1.29	47	0.65
Total	11,881	100	7,240	100

Notes: Beneath each country's name, the level of market access that such country has (will) (grant)ed of its export portfolio to his partner is displayed; in quantity (N°) and share (%). Contingent concession refers to specific products that are subject to certain criteria or requirements being met. For instance, imports that cause damage or threat to a local industry that produces a similar good. Data coming from [MinRE \(2023\)](#). [\[Return to text\]](#)

Table B5: Summary Statistics - CEPII Gravity Database

Variable	CEPII Gravity Database					Sample		
	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exports	366,826	8.88	3.78	0	19.98	119,809	10.28	3.74
Imports	394,719	8.51	4.06	0	20.14	123,427	10.16	3.94
Trade Flow	415,631	8.66	4.01	0	20.03	155,183	10.22	3.81
Exporter's GDP	631,462	17.50	2.21	11.74	23.85	162,328	18.72	1.91
Importer's GDP	631,462	17.50	2.21	11.74	23.85	162,328	18.72	1.91
Exporter's GDP per capita	631,462	14.46	21.33	0.06	193.89	162,328	20.37	21.53
Importer's GDP per capita	631,462	14.46	21.33	0.06	193.89	162,328	20.37	21.53
Population	676,162	40,678	147,495	15.69	1,412,360	167,787	57,609	189,961
H-Distance	666,939	7,564	4,497	0	19,845	164,450	7,615	4,723
Active FTA	666,939	0.13	0.34	0	1	164,450	0.24	0.43
Member WTO	709,523	0.79	0.40	0	1	179,982	0.97	0.15
Member GATT	709,523	0.88	0.32	0	1	179,982	0.92	0.27
Landlocked	710,432	0.18	0.38	0	1	180,353	0.15	0.36
Common border	666,939	0.02	0.13	0	1	164,450	0.02	0.15
Common colony	621,549	0.08	0.27	0	1	157,830	0.04	0.21
Common religion	630,754	0.19	0.26	0	1	151,346	0.22	0.29
Common language	621,549	0.14	0.35	0	1	157,830	0.14	0.34
Common legal origin	666,811	0.02	0.15	0	1	164,382	0.02	0.15

Notes: Columns (1)-(5) present detailed summary statistics for the full sample (149 countries between 1990-2021), while columns (6)-(8) present basic summary statistics for the analysis sample (103 countries between 2005-2021) in CEPII's Gravity Database. Variables related to (or constructed using) Exports, Imports, and GDP (except per capita), before transforming to ln, are measured in USD (thousands). Population is measured in inhabitants (thousands). H- Distance is measured in km. Values below 1,000 are displayed with two decimal places, while those above 1,000 are rounded to the nearest unit. The number observations might differ within variables due to missing values and/or data filtering. [\[Return to text\]](#)

Table B6: Summary Statistics - CEPII BACI Database

Variable	CEPII BACI Database					Sample		
	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Panel A: World</i>								
Trade Flow	3,205,656	5.86	4.13	0	19.35	1,980,977	6.73	4.10
Quantity	3,205,656	103.45	275.40	0	4,080	1,980,977	140.18	327.65
Density	3,174,504	2.67	838.42	0	1,407,473	1,966,529	2.91	1,038
<i>Panel B: Colombia to ROW</i>								
Trade Flow	29,609	5.35	3.75	0	16.59	23,706	6.07	3.52
Quantity	29,609	45.70	114.33	0	1,660	23,706	55.88	125.65
Density	29,395	1.23	13.74	0	762.76	23,575	1.41	13.82
<i>Panel C: Korea to ROW</i>								
Trade Flow	36,674	7.93	3.77	0	18.28	26,519	8.55	3.70
Quantity	36,674	193.33	352.62	0	3,262	26,519	236.81	394.71
Density	36,570	1.43	86.34	0	16,427	26,473	1.77	101.41

Notes: Columns (1)-(5) present detailed summary statistics for the full sample (142 countries between 2005-2022), while columns (6)-(8) present basic summary statistics for the analysis sample (100 countries between 2005-2022) in CEPII's BACI Database. Distinct from Table B5, Guadalupe, Puerto Rico, and Taiwan were not present in the scope, therein lies the difference in country count (i.e., 103 vs. 100). The unit of measurement for Trade Flow, before transforming to ln, is USD (thousands), and for Quantity is metric tons. Density variable is USD (thousands) per metric ton. Values below 1,000 are displayed with two decimal places, while those above 1,000 are rounded to the nearest unit. The number observations might differ within Panels due to missing values and/or data filtering. Acronym *ROW* stands for Rest of the World. [\[Return to text\]](#)

Table B7: Mean Differences by Regions

Variable	East and Southeast Asia			Latin America and the Caribbean			Difference	
	Obs.	Mean	SD	Obs.	Mean	SD	(2)-(5)	SE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exports	14,033	11.72	3.68	23,729	9.15	3.45	2.57***	0.04
Imports	13,236	11.73	3.79	26,323	9.16	3.51	2.57***	0.04
Trade Flow	20,467	11.82	3.52	31,655	9.15	3.42	2.67***	0.03
Exporter's GDP	17,304	19.67	2.02	35,329	18.01	1.62	1.66***	0.02
Importer's GDP	20,488	18.72	1.91	34,672	18.72	1.91	0.00	0.02
Exporter's GDP per capita	17,304	22.50	17.97	35,329	7.45	5.79	15.05***	0.14
Importer's GDP per capita	20,488	20.37	21.53	34,672	20.37	21.53	0.00	0.19
Population	17,304	177,301	399,164	37,183	27,834	46,441	149,467***	3,043
H-Distance	16,720	10,717	4,849	36,784	8,452	4,854	2,265***	45.28
Active FTA	16,720	0.14	0.34	36,784	0.15	0.35	-0.01***	0.00
Member WTO	22,526	0.97	0.16	38,522	0.98	0.12	-0.01***	0.00
Member GATT	22,526	0.88	0.32	38,522	0.95	0.22	-0.07***	0.00
Landlocked	22,763	0.08	0.27	38,522	0.16	0.37	-0.08***	0.00
Common border	16,720	0.01	0.08	36,784	0.03	0.16	-0.02***	0.00
Common colony	16,380	0.07	0.25	36,036	0.01	0.11	0.06***	0.00
Common religion	16,040	0.06	0.16	35,288	0.36	0.35	-0.30***	0.00
Common language	16,380	0.07	0.26	36,036	0.21	0.41	-0.14***	0.00
Common legal origin	16,662	0.01	0.10	36,784	0.00	0.05	0.01***	0.00

Notes: Columns (1)-(6) present basic summary statistics for a partial analysis sample (35 countries between 2005-2021) in CEPII's Gravity Database by aggregating into two regions: East and Southeast Asia, and Latin America and the Caribbean, while columns (7)-(8) show mean differences (assuming unequal variances). Countries considered for *ESEA* were: Brunei Darussalam, Cambodia, China, Korea, Philippines, Hong Kong, Indonesia, Japan, Malaysia, Singapore, Thailand, Taiwan, and Vietna, while countries for *LAC* were: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guadeloupe, Guyana, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Dominican Republic, Uruguay, and Venezuela. Variables related to (or constructed using) Exports, Imports, and GDP (except per capita), before transforming to ln, are measured in USD (thousands). Population is measured in inhabitants (thousands). H-Distance is measured in km. Values below 1,000 are displayed with two decimal places, while those above 1,000 are rounded to the nearest unit. The number observations might differ within Panels due to missing values and/or data filtering. *p<0.10, **p<0.05, ***p<0.01. [\[Return to text\]](#)

C Structural Gravity System

C1 Variables and Parameters

Index

i	Exporting country to $-i$, i.e., $j \neq i$
j	Importing country from $-j$, i.e., $i \neq j$
t	Period of time, i.e., year
v	Variety of the good produced in country i
k	Sector of the economy in country i

Variable

U_i	Utility function of consuming goods in country i
V_i^k	Range of varieties of the goods produced by sector k in country i
$x_i^k(v)$	Good quantity of variety v from sector k produced in country i
$p_i^k(v)$	Good unit price of variety v from sector k produced in country i
E_i^k	Total expenditure on goods in sector k in country i
X_i^k	Total goods quantity from sector k produced in country i
P_j^k	CES price index for sector k in country j
N_i^k	Number of active producing firms in sector k in country i
$\pi_i^k(v)$	Profits from producing a good with variety v in sector k in country i
X_{ij}^k	Trade flows value from sector k between country i to j
Π_i^k	Outward multilateral resistance of sector k in country i
γ_i^k	Income from sales of locally made varieties of sector k in country i
Y^k	Worldwide income of sector k

Parameter

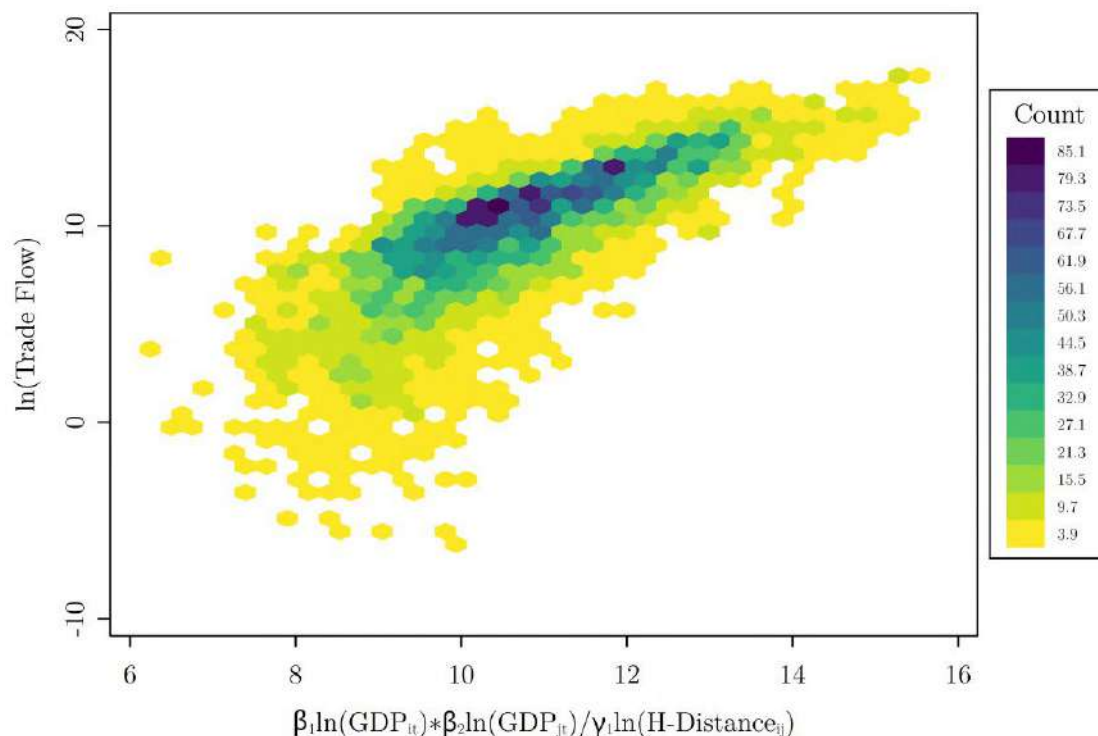
σ_k	Elasticity of substitution between goods from sector k
f_i^k	Fixed cost of producing one good unit in sector k in country i
w_i^k	Wage rate paid to workers in sector k in country i
α_i^k	Variable cost of producing one good unit in sector k in country i
τ_{ij}^k	Bilateral cost of trading goods in sector k between country i to j

Notes: i) all indexed expressions to i , j , and pairs ij are bidirectional, meaning that i shall be j when j is i (and reciprocally); ii) all unindexed expressions to country i are considered aggregates of countries, meaning they are summed over the total number of countries, C ; iii) all unindexed expressions to sector k are considered aggregates within the economy of i , meaning they are summed over the total number of sectors, K ; iv) for visual simplicity, all variables are indexed to t (hidden). [\[Return to text\]](#)



D Synthetic Control Method

Figure D1: Potential Donor Pool Units Identification



Notes: The hexbin plots the logarithmic exports value in USD (millions) against the “gravity ratio” of each potential donor pool unit between 2005-2015 after restricting the analysis sample in accordance with the criteria detailed in Subsections 3.2 and 3.3. [\[Return to text\]](#)

Table D1: Predictor Balance Prior to 2016 for COL-KOR and KOR-COL Estimates

Predictor Variable (2005-2015)	Unit	COL-KOR			KOR-COL		
		Actual	Synthetic	Weight	Actual	Synthetic	Weight
$Trade\ Flow_{ij(t-1)}$	USD	242.231	252.593	0.334	1,413	1,429	0.365
$Trade\ Flow_{ij(t-2)}$	USD	529.862	492.205	0.228	1,616	1,591	0.201
$Trade\ Flow_{ij(t-3)}$	USD	240.436	287.564	0.121	1,246	1,329	0.133
GDP_{it}	USD	2,764	5,502	0.045	1,141	1,794	0.055
GDP_{jt}	USD	1,141	2,910	0.034	2,760	5,148	0.049
$H - Distance_{ij}$	km	14,744	13,862	0.108	14,744	14,460	0.112
$Remoteness_{it}$	-	55.214	57.250	0.066	12.716	22.914	0.022
$Remoteness_{jt}$	-	12.717	22.449	0.064	55.215	57.552	0.063

Notes: Beneath each treated unit, the values from the actual and synthetic predictor variable between 2005-2015. Trade Flow and GDP are measured in millions. $Remoteness_{it}$ and $Remoteness_{jt}$ are indexes that compare the relative ease of trading between different country-pairs so they do not have an specific dimension/unit. Values below 1,000 are displayed with three decimal places, while those above 1,000 are rounded to the nearest unit. [\[Return to text\]](#)

Figure D2: Synthetic Counterfactuals Estimates by Sector-Group, Trade Creation

Sector-Group: Animal

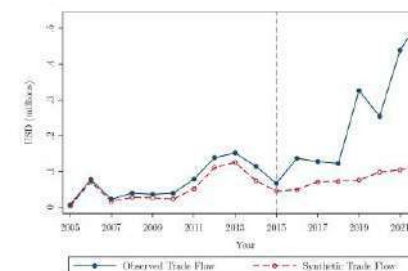
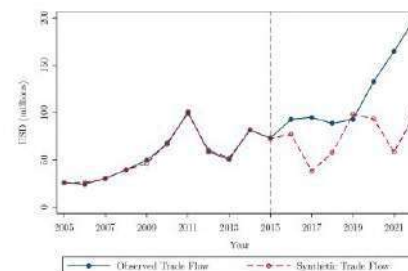
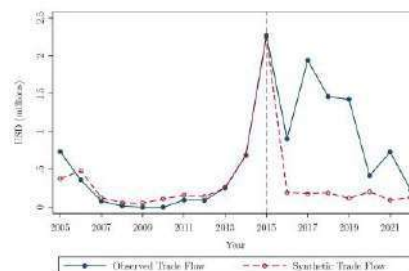
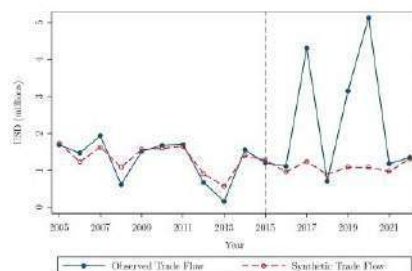
Sector-Group: Vegetable

(a1) COL-KOR

(b1) KOR-COL

(a2) COL-KOR

(b2) KOR-COL



Sector-Group: Foodstuffs

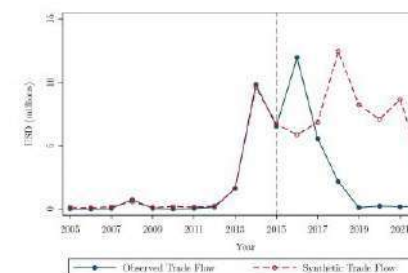
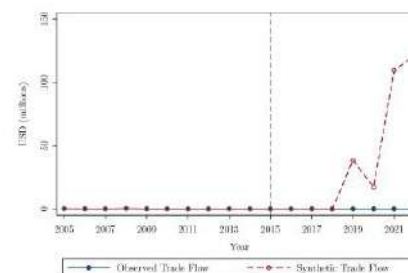
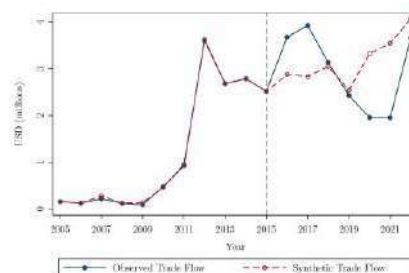
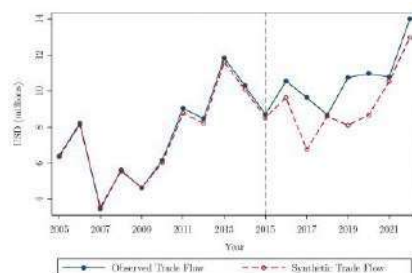
Sector-Group: Minerals

(a3) COL-KOR

(b3) KOR-COL

(a4) COL-KOR

(b4) KOR-COL



Sector-Group: Fuels

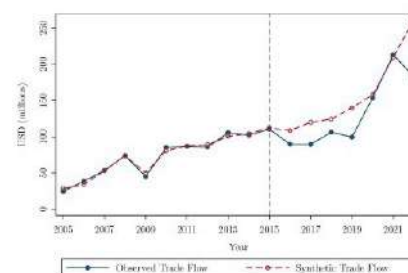
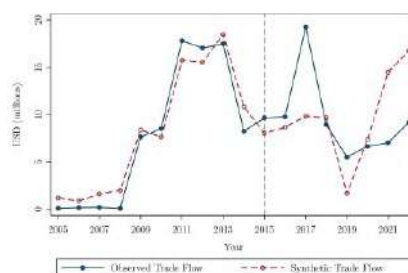
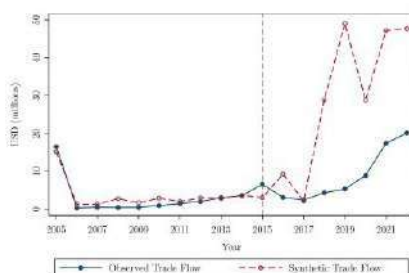
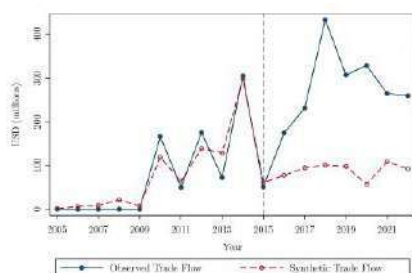
Sector-Group: Chemicals

(a5) COL-KOR

(b5) KOR-COL

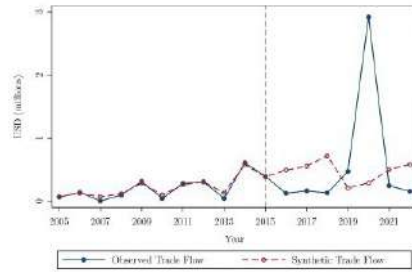
(a6) COL-KOR

(b6) KOR-COL

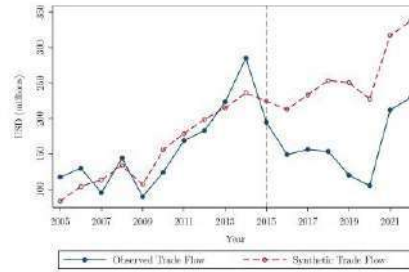


Sector-Group: Plastic/Rubber

(a7) COL-KOR

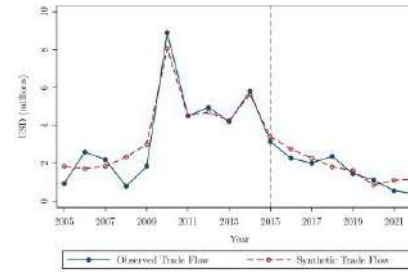


(b7) KOR-COL

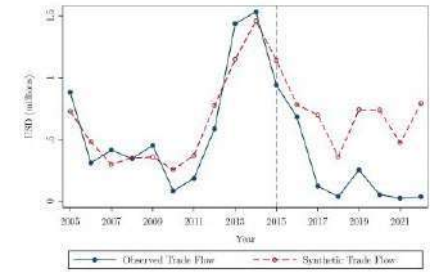


Sector-Group: Hides/Skins

(a8) COL-KOR

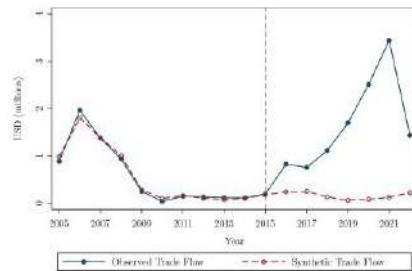


(b8) KOR-COL

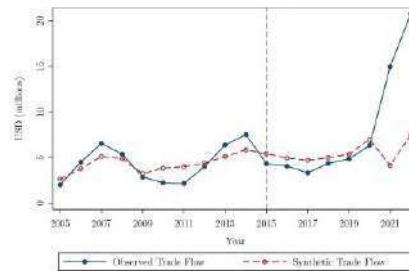


Sector-Group: Wood

(a9) COL-KOR

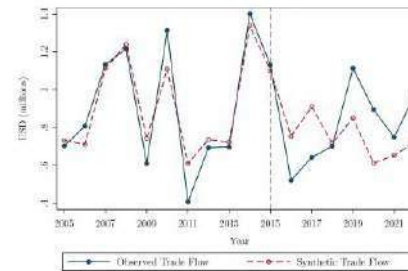


(b9) KOR-COL

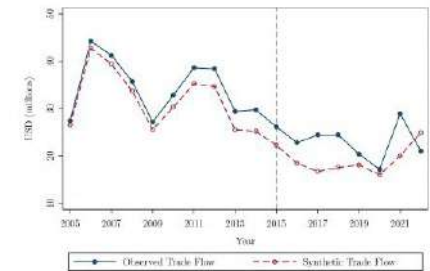


Sector-Group: Textiles/Clothing

(a10) COL-KOR

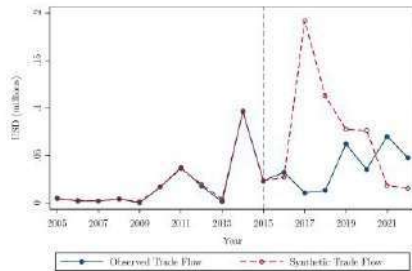


(b10) KOR-COL

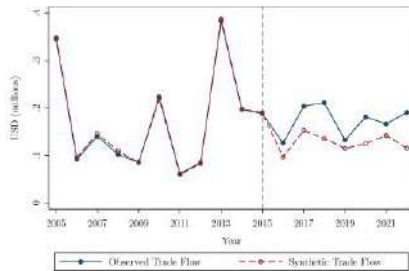


Sector-Group: Footwear

(a11) COL-KOR

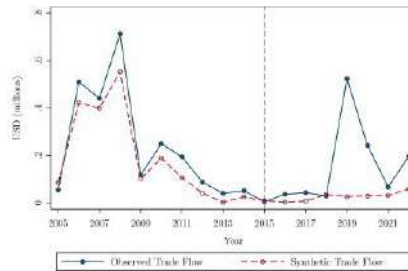


(b11) KOR-COL

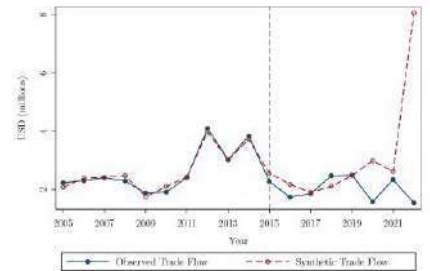


Sector-Group: Stone/Glass

(a12) COL-KOR

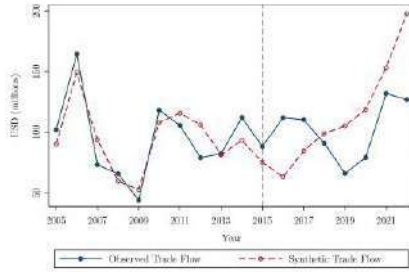


(b12) KOR-COL

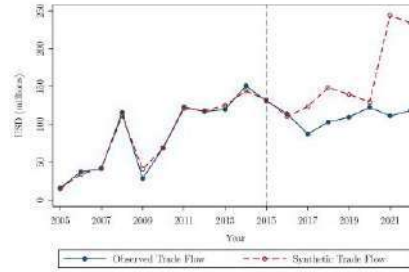


Sector-Group: Metals

(a13) COL-KOR

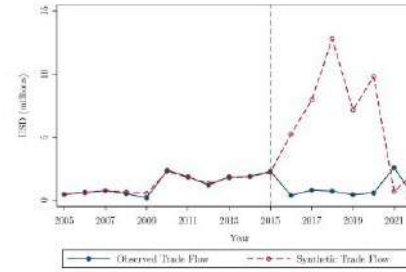


(b13) KOR-COL

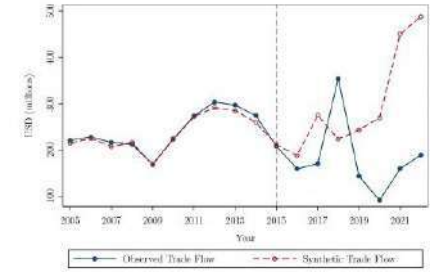


Sector-Group: E-Machinery

(a14) COL-KOR

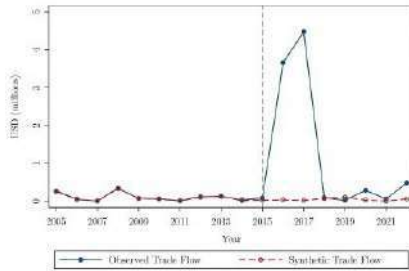


(b14) KOR-COL

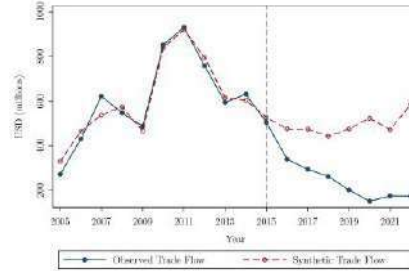


Sector-Group: Transportation

(a15) COL-KOR

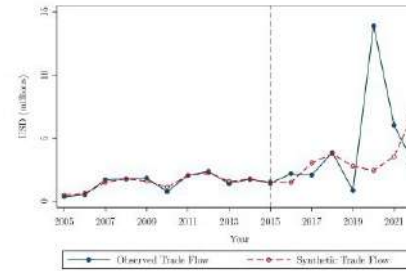


(b15) KOR-COL

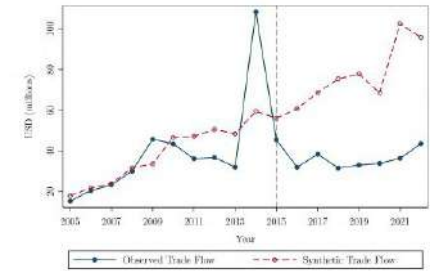


Sector-Group: Miscellaneous

(a16) COL-KOR



(b16) KOR-COL



Notes: Panels (1a)-(16b) plot the actual -blue solid line- and synthetic counterfactual -red solid line- trade flows in USD (millions) for each treated unit by Sector-Group (k) between 2005-2022. A time threshold is set to 2015 (synthetic 2016 is predicted). [[Return to text](#)]



E Robustness Checks

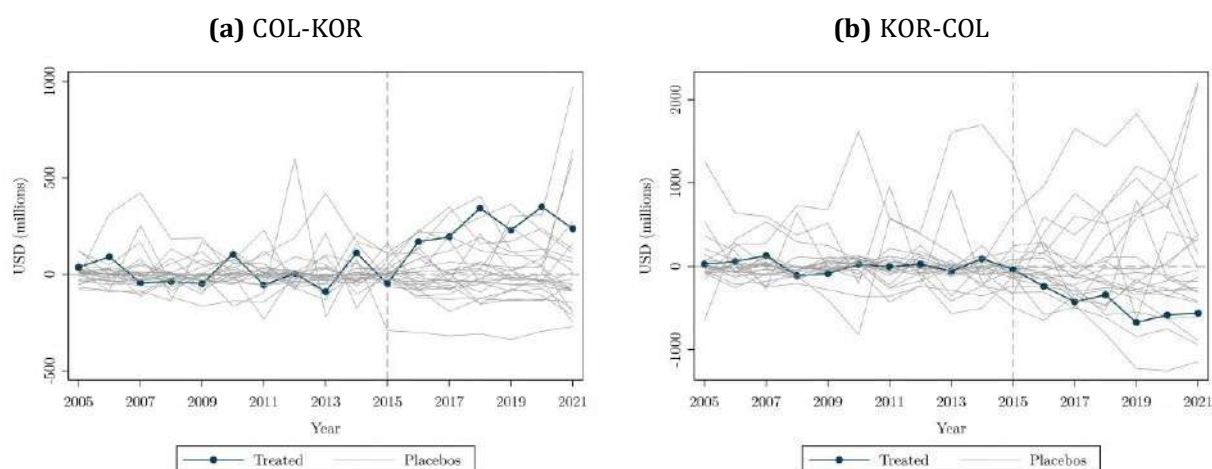
Table E1: Gravity Model Complementary Estimates

Variable	PPML					
	(1)	(2)	(3)	(4)	(5)	(6)
<i>FTA COL – KOR_{ijt}</i>	0.021 (0.356)		0.027 (0.346)		0.124 (0.163)	
<i>TF COL – KOR_{ijt}</i>		1.022*** (0.110)		0.936*** (0.098)		0.591*** (0.115)
<i>TF KOR – COL_{ijt}</i>		-0.333*** (0.060)		-0.324*** (0.061)		-0.021 (0.056)
<i>IMP COL – LAC_{ijt}</i>	-0.151 (0.101)	-0.168 (0.101)	-0.109 (0.136)	-0.126 (0.137)	-0.132 (0.116)	-0.136 (0.117)
<i>IMP COL – ESEA_{ijt}</i>	0.251*** (0.072)	0.234** (0.073)	0.146*** (0.052)	0.129** (0.056)	0.235*** (0.060)	0.230*** (0.061)
<i>IMP KOR – LAC_{ijt}</i>	0.274 (0.177)	0.276 (0.177)	0.165 (0.153)	0.167 (0.153)	0.232 (0.172)	0.233 (0.172)
<i>IMP KOR – ESEA_{ijt}</i>	0.030 (0.072)	0.032 (0.072)	0.003 (0.060)	0.004 (0.060)	-0.002 (0.071)	-0.001 (0.071)
<i>EXP COL – LAC_{ijt}</i>	0.359* (0.192)	0.375*** (0.190)	0.530*** (0.128)	0.545*** (0.126)	0.450** (0.179)	0.454** (0.179)
<i>EXP COL – ESEA_{ijt}</i>	0.380*** (0.103)	0.397** (0.099)	0.258** (0.115)	0.274** (0.113)	0.368*** (0.108)	0.373*** (0.107)
<i>EXP KOR – LAC_{ijt}</i>	-0.139 (0.120)	-0.141 (0.120)	-0.155 (0.111)	-0.157 (0.111)	-0.188* (0.103)	-0.188* (0.103)
<i>EXP KOR – ESEA_{ijt}</i>	-0.017 (0.102)	-0.019 (0.102)	0.006 (0.080)	0.004 (0.080)	-0.033 (0.093)	-0.034 (0.000)
<i>Constant</i>	16.458*** (0.072)	16.458*** (0.072)	16.276*** (0.070)	16.276*** (0.070)	16.515*** (0.109)	16.515*** (0.109)
Observations	398,091	398,091	195,942	195,942	143,163	143,163
Clusters	18,860	18,860	18,051	18,051	9,077	9,077
Others	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1)-(6) present the results using a Poisson Pseudo-Maximum Likelihood (PPML) estimator based on multiplicative form. Columns (1) and (2) use the full sample and a first robust time frame (149 countries between 1995-2021), columns (3) and (4) use the full sample and a secondary robust time frame (149 countries between 2010-2021), and columns (5) and (6) use the analysis sample (103 countries between 2005-2021) excluding (5) Fuels and (15) Transportation Sector-Groups from Colombia's and Korea's trade flows, respectively. Others include two control variables for time-varying drivers of bilateral trade flows: *FTA_{ijt}* and *WTO_{ijt}*, and three-way fixed effects, i.e., exporter-time, importer-time, and exporter-importer. Standard errors clustered by country-pair in parenthesis.

*p<0.10, **p<0.05, ***p<0.01. [[Return to text](#)]

Figure E1: Spatial Placebo Test for COL-KOR and KOR-COL Estimates, Trade Creation



Notes: Panels (a) and (b) plot the net gap between the observed and synthetic trade flows in USD (millions) for each placebo unit -light gray solid lines- and the actual treated unit -blue solid line- between 2005-2021. Placebo donor pool units for Panel (a) are: ARG-TWN, ARG-HKG, ARG-PHL, ARG-THA, BOL-CHN, BOL-JPN, CHL-HKG, CHL-IDN, CHL-MYS, CHL-SGP, CHL-VNM, CRI-CHN, CRI-JPN, CRI-MYS, DOM-CHN, DOM-JPN, ECU-JPN, HDN-CHN, MEX-IDN, MEX-THA, PAN-CHN, PAN-TWN, PAN-JPN, VEN-HKG, VEN-JPN, while for Panel (b) are: CHN-BOL, CHN-CRI, CHN-CUB, CHN-DOM, CHN-ECU, CHN-SLV, CHN-PRY, CHN-URY, HKG-BRA, HKG-MEX, HKG-PAN, IDN-BRA, IDN-MEX, JPN-ARG, JPN-PER, MYS-BRA, PHL-MEX, SGP-BRA, SGP-MEX, VNM-BRA, THA-BRA, THA-MEX. ISO 3166-1 alpha-3 country codes are: ARG, Argentina; TWN, Taiwan; HKG, Hong Kong; PHL, Philippines; BOL, Bolivia; CHN, China; JPN, Japan; CHL, Chile; IDN, Indonesia; MYS, Malaysia; SGP, Singapore; VNM, Vietnam; CRI, Costa Rica; DOM, Dominican Republic; ECU, Ecuador; HDN, Honduras; MEX, Mexico; PAN, Panama; VEN, Venezuela; CUB, Cuba; SLV, El Salvador; PRY, Paraguay; URY, Uruguay, and BRA, Brazil. A time threshold is set to 2015 (synthetic 2016 is predicted). [\[Return to text\]](#)

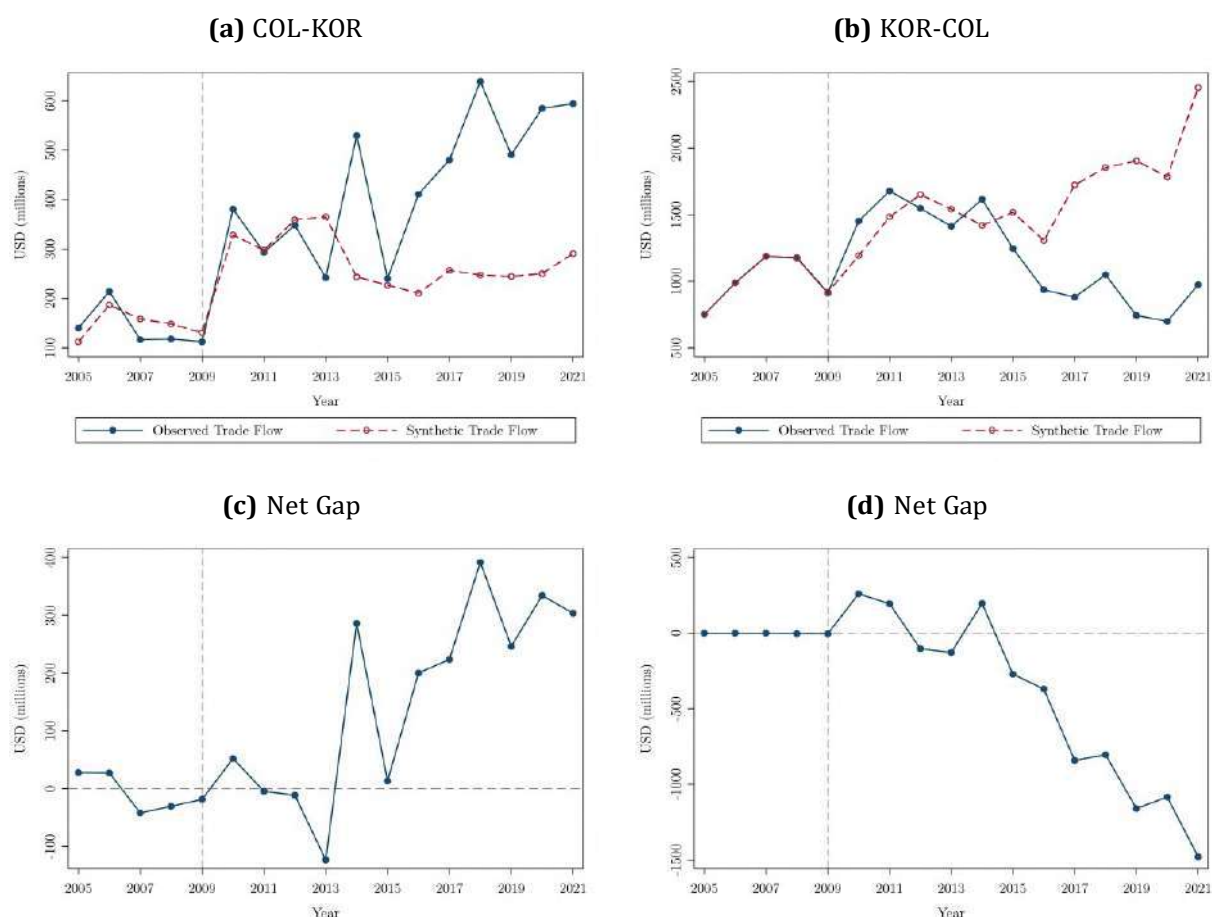
Table E2: Standardized Probabilistic Value for Estimated Periods, Trade Creation

Treated Unit	2016	2017	2018	2019	2020	2021
COL-KOR	0.131	0.172	0.144	0.093	0.063	0.105
KOR-COL	0.136	0.045	0.092	0.001	0.090	0.102

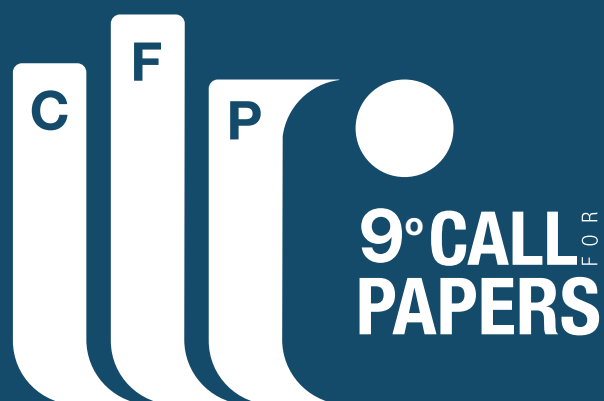
Notes: Beneath each year, the standardized probabilistic value, i.e., *p-value*, for each treated unit computed as the proportion of country-pairs from the *ad-hoc* constrained donor pool with a larger net trade creation effect (in absolute value). [\[Return to text\]](#)



Figure E2: Temporal Placebo Test for COL-KOR and KOR-COL Estimates, Trade Creation



Notes: Panels (a) and (b) plot the observed -blue solid line- and synthetic counterfactual -red dashed line- trade flows, while Panels (c) and (d) plot the net gap in USD (millions) for each treated unit between 2005-2021 setting 2010 as a temporal placebo date. Selected donor pool units for Panel (a) were: CHL-THA (0.373), PAN-MYS (0.294), PAN-THA (0.287), VEN-TWN (0.029), and VEN-JPN (0.017), while for Panel (b) were: JPN-VEN (0.426), HKG-ARG (0.172), JPN-CUB (0.094), CHN-MEX (0.026), and Others (0.282). ISO 3166-1 alfa-3 country codes are: CHL, Chile; THA, Thailand; PAN, Panama; MYS, Malaysia; VEN, Venezuela; TWN, Taiwan; JPN, Japan; HKG, Hong Kong; ARG, Argentina; CUB, Cuba; CHN, China, and MEX, Mexico. A time threshold is set to 2009 (synthetic 2010 is predicted). [\[Return to text\]](#)



Contribuyendo al desarrollo
del sistema financiero

Carlos A. Ballesteros

Santiago Novoa

César E. Tamayo

Alejandro Torres

***LIQUIDITY REQUIREMENTS,
FINANCIAL MARKETS AND
MACROECONOMIC
PERFORMANCE****

Liquidity Requirements, Financial Markets and Macroeconomic Performance*

June 2025

Abstract

We study the effect of liquidity regulations on financial markets and the macroeconomy. Using different samples of countries and time periods, and a variety of empirical methods, we provide comprehensive evidence that such regulations have helped build sounder banking systems worldwide, although their impact on lending is less one-sided. To account for these findings, we develop a model in which both saving and lending happen under asymmetric information, and bank failure risk introduces a role for liquidity requirements. When using the model to investigate the macroeconomic implications of such requirements, we find that the effects on steady-state consumption, investment and output depend critically on the severity of agency problems. In general, liquidity regulations make macro variables less procyclical, but the intensity of this effect also depends on financial frictions.

Keywords: Basel III, liquidity requirements, financial stability, DSGE models, financial frictions.

JEL Classification Numbers: E32, E58, E61.

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1 Introduction

Among other things, banks exist to provide society with appropriate maturity transformation in financial assets. Nonetheless, a wide array of studies has shown that when taken to extremes, this function can put financial systems at risk¹. Accordingly, in recent decades there has been a worldwide effort to lower excessive maturity mismatch risk within banks, including the adoption of liquidity regulations codified in the Basel III Accords.

Provisions such as the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR) from Basel-III, aim at promoting the short-term resilience of a bank's liquidity risk profile. However, our understanding of the effectiveness and mechanisms of such provisions is still limited.

In this paper, we study how Basel-type liquidity regulations impact financial markets and macroeconomic performance. To do so, we begin by providing comprehensive evidence that adoption of the LCR has resulted in more stable banking systems around the world. First, long-run (2000-2021) panel data from a large pool developed and developing countries show that countries which increase their LCR over time end up with higher values of average bank Z-scores -a measure of bank's distance to default that is widely used to assess bank's probability of failing-. Secondly, additional quasi-experimental evidence from event studies of the LCR adoption by Basel signatory countries further confirms the positive -and likely causal- relationship between liquidity regulations and banking sector Z-scores. Finally, using data from the pandemic years, we are also able to show that promoting higher liquid asset ratios most likely provided countries with protection against shocks. That is, countries where banking systems held more liquid assets ratios (relative to the 50th or 75th-percentile country) experienced lower growth in non-performing loans in the quarters that followed the Covid-19 shock.

Evidence on the effect of liquidity requirements on lending is less clear-cut. On the one hand, panel regressions show some weak evidence that increasing country-wide LCR may reduce credit-to-GDP growth in the long run. On the other hand, in event studies, the adoption of LCR requirements *per se* does not appear to have any statistically significant causal effect on lending growth, but is likely to mitigate the impact of aggregate shocks on credit supply.

We develop a novel quantitative general equilibrium framework that can account for this evidence, and use it for assessing the aggregate consequences of Basel-type liquidity regulations in the long-run (steady-state) and in the face of aggregate shocks. The model features agency problems (monitoring costs) between banks and firms, as in [Bernanke et al. \(1999\)](#), and between banks and depositors, as in [Gertler and](#)

¹See [Hellwig \(2009\)](#), [Vazquez and Federico \(2015\)](#), [IMF \(2013\)](#), among others.

[Karadi \(2011\)](#). The latter implies that bank net worth is an additional endogenous state variable, allowing us to study how LCR policy affects banking decisions and macroeconomic outcomes thereof. Bankers may expect an outflow of a fraction of their deposits and thus are required to hold a fraction of them as liquid assets (i.e., not lend).

Introducing liquidity regulations reduces bank leverage, business lending, and the probability of bank failure in the long run, consistent with our empirical evidence. By forcing banks to keep a fraction of their deposits saved, the LCR regulation triggers a downward-left shift in the banks' demand curve for deposits. Everything else equal, this diminishes equilibrium deposits interest rate and quantities, lowering the availability of loanable funds and shifting the banks' supply curve for credit to the left.

Furthermore, negative aggregate (productivity) shocks in this model increase firms' default probabilities less than in the economy without regulation, again, consistent with the empirical evidence regarding non-performing loans. This follows directly from the fact that higher cost of external financing makes entrepreneurs substitute credit for own net worth.

The results summarized up to this point are independent of the degree of asymmetric information present in the economy. On the other hand, macroeconomic effects of liquidity regulations are very much dependent upon the severity of financial frictions. In an economy where financial frictions are mild, these regulations reduce steady-state investment and output, but the opposite is true when financial frictions are very severe. This leaves us a set of economies with intermediate levels of financial frictions, in which there might be an optimal level of LCR that lies between 0 and 1.

Responses to aggregate shocks also depend on the prevalence of financial frictions. Liquidity requirements make consumption, investment and output less procyclical, under mild agency problems but not under severe financial frictions. Interestingly, liquidity regulations make credit less procyclical when monitoring costs are high, but less procyclical when they are low, which can explain why empirical evidence surrounding the effect of LCRs on lending is mixed.

Our paper is related to at least two strands of the literature on financial markets and macroeconomics. First, some authors have studied the effects of liquidity regulations on bank lending and bank performance.² [Sundaresan and Xiao \(2024\)](#) finds that liquidity regulations improved financial stability in the U. S. during 2011-2017, and [Sharma and Chauhan \(2023\)](#) finds a similar result for 10 developing economies in the period 2014-2021. Further, [L'Huillier et al. \(2018\)](#), using data from 647 banks of 47 countries (32 of which are low and middle income nations) between 2003 and 2013,

²This is in addition to the large body of research studying the effect of Basel-type capital requirements on financial stability, credit expansion and business cycles (see, for instance, [Zhu \(2007\)](#); [Covas and Fujita \(2009\)](#); [Angeloni and Faia \(2013\)](#))



found empirically that NSFR is positively related with the stability of banks (captured by their Z-score). This is consistent with [Hossain et al. \(2018\)](#) findings, who evaluates the LCR of 57 banks from BRICS economies between 2007 and 2015, and identifies a direct and statistically significant association between the accomplishment of this regulation and banking resilience (measured by the Z-score).

By contrast, the empirical evidence of the effects of liquidity regulations on credit is less clear. For instance, [BIS \(2022\)](#) finds no effects of LCR on credit during 2011-2019, much like [Banerjee and Mio \(2018\)](#) which finds no effect of liquidity regulations on credit in UK during 2010-2012. Nevertheless, [Sharma and Chauhan \(2023\)](#) finds that the LCR had a positive effect on credit growth in 10 developing economies during 2014-2021, while [Bonner and Eijffinger \(2016\)](#) finds a positive effect on long-term borrowing in Netherlands during 2004-2011 and [Roulet \(2018\)](#) finds a positive effect for European countries in the period 2008-2015. At the other end, [Roberts et al. \(2023\)](#) and [Sundaresan and Xiao \(2024\)](#) find that liquidity regulations had a negative effect on borrowing in U.S. banks during 2011-2017, while [Mutarindwa et al., 2020] estimate that, in African countries, banks complying with liquidity regulations such as the NSFR tend to lend less to nonfinancial firms.

A second branch of the literature aims at understanding the transmission mechanisms of banking regulations associated with liquidity and capital constraints in the spirit of Basel III. For instance, [Boissay and Collard \(2016\)](#) proposes a macroeconomic model in which the regulator faces a trade-off arising from the fact that banking regulation can decrease the supply of credit but can also improve its quality. They calibrate the model based on data from the U.S. economy and calculate the optimal mix of regulations to find that, in terms of welfare, there is a net gain of an optimally regulated economy in comparison to a non regulated one, which is reflected in an increase in annual permanent consumption.

[Chawwa \(2021\)](#) use a DSGE model calibrated for Indonesia to show that changes associated to the LCR regulation have consequences for the demand for government bonds, and hence for taxes, deposits, and bank profits, while helping to reduce the volatility of bank loans. Additionally, it affects credit to the extent that decreases in liquidity requirements are associated to increases in credit due to a lower interest rate on these. The model shows positive effects on stability and slightly adverse effects on credit due to increasing the LCR. Along the same lines, [Krug et al. \(2015\)](#); [Walther \(2016\)](#); [Li et al. \(2017\)](#) find that the LCR help to reduce systematic bank risk taking, but decreases credit supply. These results are at odds with those produced by the dynamic banking model of [Balasubramanyan and VanHoose \(2013\)](#), where an increase in the LCR has ambiguous effects on banking stability given that it generates interdependencies between the optimal choices that bankers make on deposits and loans.

Other equilibrium models that focus on aggregate effects of liquidity regulations include [Chadha and Corrado \(2012\)](#), which finds that the LCR helps avoid credit booms during expansionary phases of the business cycle, and [Roger and Vlček \(2011\)](#) which shows that liquidity requirements could decrease output (depending on the way the regulation is implemented), reduce bank revenues (holding more liquid assets is costly), and increase credit interest rates. [Angelini et al. \(2015\)](#), using ten DSGE models previously estimated for the European Union and the U.S. economy, conclude that the tightening of the LCR by 25% reduces the steady state output on average by 0.08% and contracts output volatility in 1%. Finally, [Van den Heuvel \(2016\)](#) uses an economic growth model to find that liquidity regulation would imply a permanent 0.03% drop in consumption.

To the best of our knowledge, our paper is the first one to simultaneously estimate and rationalize the effects of Basel-type liquidity regulations (LCR) on financial markets and the macroeconomy. From the empirical standpoint we extend the available evidence to a wider set of countries and time periods, and to the analysis of response to aggregate shocks. From a theoretical perspective, our model complements the extant literature by allowing us to study liquidity regulations in the long-run, as well as in the face of aggregate fluctuations, and under varying degrees of agency problems.

The reminder of the paper is organized as follows. The next section provides the main empirical regularities regarding LCR and financial markets. Section three presents our model, its parametrization and the counterfactual analysis, including comparative statics and transitional dynamics. Section four concludes and extracts some policy implications.

2 Empirical Regularities

In this section we provide reduced-form econometric evidence on the relationship between Basel-type liquidity restrictions and financial market outcomes. Overall, our data and methods show that such a regulation is unambiguously associated with more robust banking systems, although its impact on credit markets is less one-sided.

2.1 Data

The critical (country-level) variables for our empirical analysis refer to financial market outcomes and various bank liquidity measures (targets, observed values). We obtain the former -average bank Z-scores, aggregate credit to GDP, and non-performing loan ratios- from the World Bank's Global Financial Development Database, and the latter from the IMF's Integrated Macprudential Policy (iMaPP) Database. After excluding oil-producing and HIPIC countries, small islands, and financial centers, we are left with



a sample of between 79 and 103 countries over the 2000-2021 period, depending on the combination of dependent variables and treatment strategies.

2.2 Panel Data Regressions

Given the strong persistence observed in our dependent variables of interest (credit, Z-scores), we begin by conducting dynamic panel data regressions for the full sample of countries, using annual data for the 2000-2021 period. Specifically, we estimate the following econometric models³:

$$\ln Z_{it}^{\text{score}} = \beta_0 + \sum_{k=1}^M \theta_k \ln Z_{it-k}^{\text{score}} + \gamma_1 \Delta LCR_{it} + \psi X_{it} + \mu_i + \nu_{it} \quad (1)$$

$$\Delta \left(\frac{\text{Credit}}{\text{GDP}} \right)_{it} = \alpha_0 + \sum_{j=1}^L \alpha_j \Delta \left(\frac{\text{Credit}}{\text{GDP}} \right)_{it-j} + \gamma_2 \Delta LCR_{it} + \delta X_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

Our main coefficients of interest are γ_1 and γ_2 , which capture the direct effect of a faster LCR adoption policy. As for the control variables, we include common choices such as: (lagged) GDP growth, (lagged) deposit-to-GDP growth and a dummy for bank crises. Equations (1) and (2) are fitted using both the classic Arellano-Bond, as well as the more robust Quasi-Maximum Likelihood estimators. The results are shown in Tables 1 and 2.

	AB		DQML	
Variable	Coef.	Std. Err.	Coef.	Std. Err.
<i>ln_BankZscore (L1.)</i>	0.4981***	0.1034	0.6736***	0.0450
<i>d_lcr_int</i>	0.0923**	0.0412	0.0578**	0.0225
<i>gdp_g (L1.)</i>	-0.0039**	0.0019	-0.0012	0.0016
<i>bank_crisis</i>	-0.1641***	0.0484	-0.1129***	0.0294
Observations	1153		1061	
Groups	79		70	
Instruments	100		-	

Table 1: Regression Results - $\ln BankZscore$

Our estimations yield strong evidence that a faster LCR adoption policy is associated with greater financial stability -as measured by Z-scores. Additionally, some weak evidence is found in the direction of LCR adoption reducing the pace of credit growth.

³As shown in equations (1) and (2), we estimate the Z-score model in levels but the credit-to-GDP model in first-differences, according to our formal stationarity tests found in Appendix A.2

	AB		DQML	
Variable	Coef.	Std. Err.	Coef.	Std. Err.
<i>credit_gdp</i> (<i>LD.</i>)	0.2402***	0.0465	0.9840***	0.0736
<i>d_lcr_int</i>	0.0219	0.0650	-0.0163**	0.0078
<i>gdp_g</i> (<i>L1.</i>)	0.0035***	0.0007	0.0026***	0.0007
<i>deposits_gdp</i> (<i>D1.</i>)	0.0027**	0.0012	0.0012***	0.0003
<i>bank_crisis</i>	-0.0040	0.0115	-0.0084	0.0158
Observations	1147		1256	
Groups	82		82	
Instruments	96		-	

Table 2: Regression Results - $\Delta Credit_GDP$

2.3 Diff-in-Diff regressions and event studies

At this point we aim at coming closer to a causal interpretation of the effect that LCR has on financial market outcomes. To do so, we follow a two-way fixed-effects difference in differences (DiD) methodology, where the treatment consists on the interaction of being a Basel Accord signatory, interacted with the years in which the LCR was announced (2011), revised/‘finalized’ (2013) and enforced (2015). Specifically, we estimate the following econometric models:

$$Z_{it}^{score} = \theta_t + \eta_i + \beta^{twe} D_i \cdot Post_t + \zeta_{it} \quad (3)$$

$$\Delta \left(\frac{Credit}{GDP} \right)_{it} = \theta_t + \eta_i + \beta^{twe} D_i \cdot Post_t + \epsilon_{it}, \quad (4)$$

where $D_i = 1$ for the entire sample if country i is a Basel Accord signatory, and $Post_t = 1$ when $t > 2011$, $t > 2013$ and $t > 2015$, respectively. Given that signatory countries are bound to implement future regulations announced by the Basel Committee, we take the interaction $D_i \cdot Post_t$ as our most exogenous form of treatment. Equations (3) and (4) are estimated using both the Newey-West variance correction, and the clustering of standard errors at the country level. Results are presented in Table 3.

As in the previous exercise, these results suggest that adopting LCR standards as a consequence of Basel Committee membership caused higher (average country-level) Z-scores. However, in these estimations, liquidity regulations do not appear to have any statistically significant effect on credit to GDP growth.



	Country Clustered S.E		Newey-West S.E	
	Z Score	Δ Credit/GDP	Z Score	Δ Credit/GDP
Signatories x Post 2011	1.931*	0.171	1.931***	0.171
	(1.105)	(1.213)	(0.628)	(0.826)
Signatories x Post 2013	2.485**	0.241	2.485***	0.241
	(1.129)	(1.091)	(0.644)	(0.802)
Signatories x Post 2015	2.774**	-0.014	2.774***	-0.014
	(1.180)	(0.977)	(0.740)	(0.837)
Fixed-Effects:				
Country	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	1,637	1,879	1,637	1,879
Countries	84	103	84	103

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are shown in parentheses.

Table 3: Consolidated Results of Z Score and Δ Credit/GDP DiD

To further assess the validity of our DiD approach, we perform an event study analysis. Figure 1 below visualizes the estimated treatment effect of LCR adoption on Z-scores, over time and relative to the year before treatment. The coefficients are estimated for each year before and after treatment, with lag 1 (-1) as the reference period.

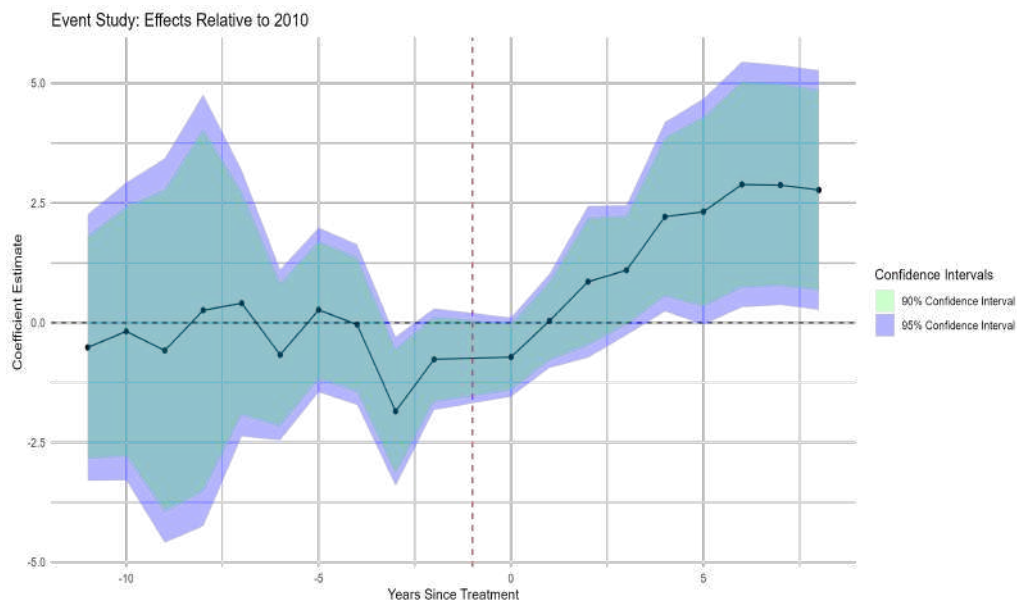


Figure 1: Impact of adopting Basel-type liquidity regulation

In Figure 1 the pre-treatment period shows coefficients hovering around zero, indicating no significant difference in Z Score trends between treated and control groups before 2011. In the post-treatment years, however, an upward trend suggests the treatment had a positive impact on Z Score, potentially enhancing financial stability.

2.4 Response to Shocks

Finally, we assess the potential effect of liquidity requirements on an economy's ability to deal with aggregate shocks by studying the Covid-19 pandemic episode. As a first exploration in figures 2 and 3 we present the cumulative (quarterly) growth of non-performing loans and total lending with respect to the reference period 2019-Q4, for two groups of countries; those with high and low average ratio of bank liquid assets to short term liabilities (above and below the median). The idea is that, while we don't have enough cross-country data on quarterly LCR requirements, we can use the average ratio of banks liquid assets as a proxy.

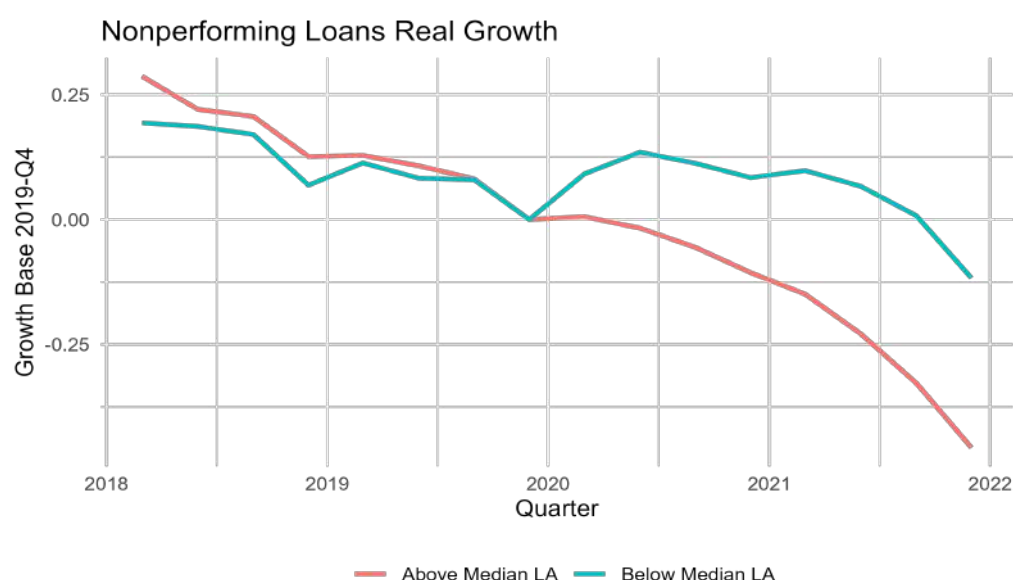


Figure 2: Cumulative Non-performing Loans Real Growth

Figure 2 suggests that a secular downward trend in non-performing loans was temporarily reversed after the Covid shock in countries with relatively low levels of liquid assets. Figure 3 tells us that the effects in total lending are much less clear, although a timid change of trend toward less lending growth is observed in countries with (relatively) low levels of liquid assets.

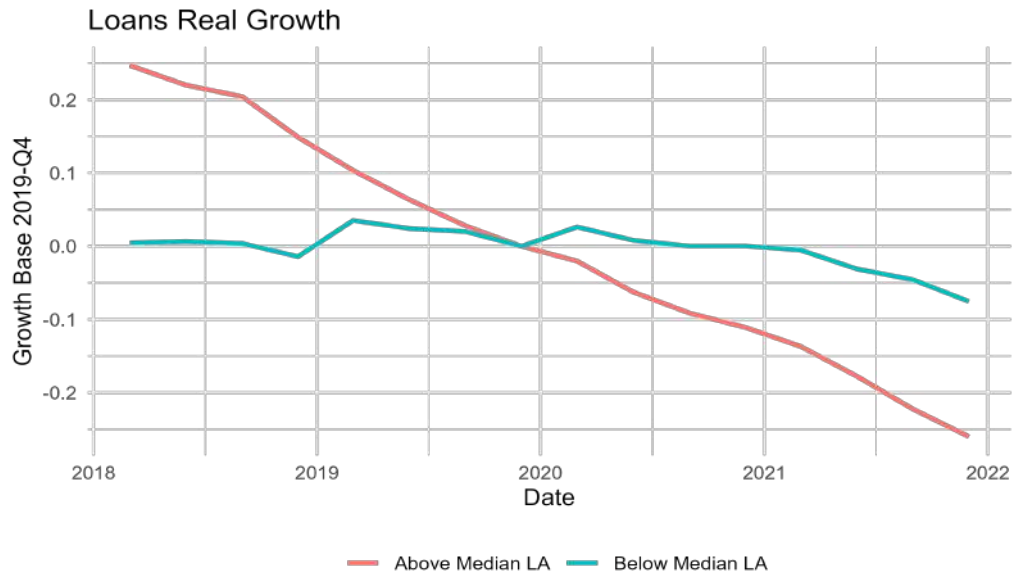


Figure 3: Cumulative Loans Real Growth

To further assess whether the Covid shock had heterogeneous effects based on pre-pandemic liquidity conditions, we estimate the following event study for nonperforming loans:

$$y_{it} = \theta_t + \eta_i + \sum_{\substack{k=-K \\ k \neq 0}}^K \beta_k D_{it,k} + \nu_{it}, \quad (5)$$

We keep the same two groups according to their pre-pandemic liquid assets to short-term liabilities ratio and the dependent variable corresponds to nonperforming loans' real growth with base 2019-Q4. The event study shown in Figure 4 captures the dynamic effects of the shock over time.

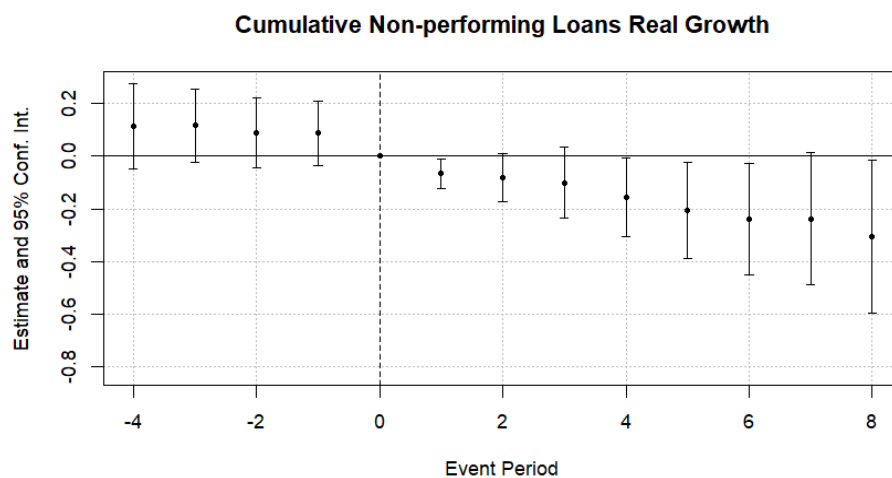


Figure 4: Cumulative Non-performing Loans Real Growth Event Study

3 A macroeconomic model with Basel-type liquidity requirements

We propose a general equilibrium model with financial frictions to study the effects of the liquidity requirements (particularly LCR) on the financial sector (banks) decisions and its consequences on the main macroeconomic variables. The model features agency problems between bankers and entrepreneurs, as in [Bernanke et al. \(1999\)](#), and between bankers and depositors, as in [Gertler and Karadi \(2011\)](#). This introduces the possibility of bank failure, and allows us to study the behavior of bankers' net worth. Importantly, we introduce a regulatory authority which can implement banking liquidity regulations, changing the banks optimal decisions in terms of deposits demand and credit supply.

3.1 Model overview

The model economy is comprised of four agents: entrepreneurs, bankers, households (consumer and depositors), and a regulatory authority. Specifically, in each period, depositors, bankers and entrepreneurs decide simultaneously the demand and supply for deposits, and demand and supply of credit, as functions of deposits and credit interest rates, for given values of initial bank and entrepreneurial net-worth. In the case of banks, their net-worth, jointly with available deposits, are used to extend credit. Moreover, entrepreneurs use credit and its net-worth to produce capital goods.

The importance of bank and entrepreneurial net worth is motivated by the existence of an asymmetric information problem between the three agents. In fact, we assume that entrepreneurs face an idiosyncratic productivity shock, which can only be observed by the bankers or depositors incurring in monitoring costs. Moreover, a second information asymmetry is introduced as we also assume that banks face an idiosyncratic productivity shock, which can only be observed by depositors incurring in monitoring costs.

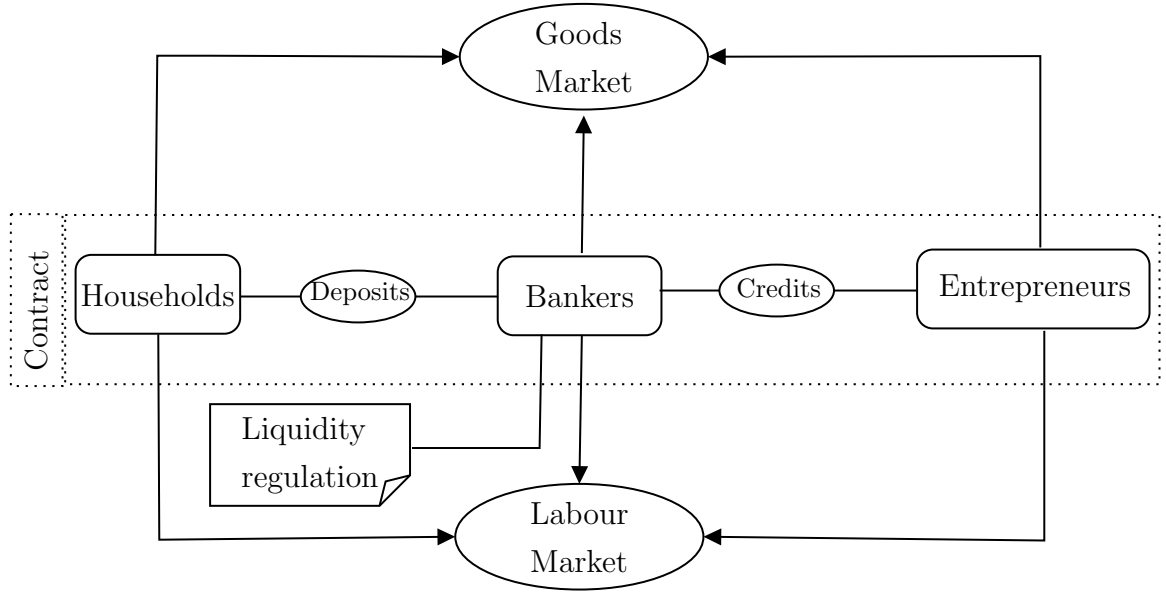
To solve the informational problem, a debt contract is designed. Solving this contract implies, on the one hand, that the interest rate of depositors negatively depends on the bank net-worth. That is, higher levels of bank net-worth reduce the interest rate that banks pay to the depositors. In the same spirit, higher levels of entrepreneurial net-worth imply lower credit interest rates or, equivalently, given a credit interest rate, higher levels of credit and investment. Thus, these interactions determine the level of new investment to be used by entrepreneurs in the production of consumption goods (output).

Here is where liquidity regulations matter. In the non-regulated scenario, the contract is optimally solved. In contrast, it is possible that a regulatory authority imposes a liquidity restriction to bankers (in the spirit of the LCR), implying that a



fraction of each unit of demanded deposits must be maintained by bankers in order to avoid a potential bank run. Then, in the regulated scenario, the contract is optimally solved subject to the LCR constraint. This implies an increase in the costs of the deposits and, consequently, their demand could vary in comparison with the non-regulated scenario. These changes not only affect the banks' demand for deposits, but also the banks' credit supply and the deposits and credit interest rates.

The rest of model is fairly standard. Entrepreneurs transform capital and labor to produce output, while households demand consumption goods and supply labor maximizing his utility function. Bank and entrepreneurial net-worth evolve over time considering their income and profits in each period. In order to guarantee that external financing is always necessary, we assume that in each period a constant fraction of bankers and entrepreneurs are out of business, consuming their remaining capital. The following scheme depicts the main relationships in the model:



Scheme of the model

3.2 The contract

The capital that each entrepreneur j needs for the next period (K_{t+1}^j) is purchased with a combination of net-worth in that period (N_{t+1}^j), and the credit (B_{t+1}^j) extended by the bank:

$$Q_t K_{t+1}^j = N_{t+1}^j + B_{t+1}^j \quad (6)$$

Banks use their net-worth (M_{t+1}^j) and deposits (D_{t+1}^j), to produce loans (B_{t+1}^j):

$$B_{t+1}^j = M_{t+1}^j + D_{t+1}^j \quad (7)$$

Interactions among lenders and debtors are ruled by an asymmetric information

problem *à la* BGG: entrepreneurs obtain a revenue from their capital, which depends on its marginal product (R_{t+1}^k), and an idiosyncratic shock (ω) which follows a log-normal probability distribution, with cumulative distribution function $F(\omega)$ and a marginal distribution function $f(\omega)$.

Entrepreneurs are the only agents who can costlessly observe their idiosyncratic shock, and its realization determines both the ability of entrepreneurs to pay their debts to banks, and the ability of banks to pay their debts to households.

The gross income that entrepreneurs receive for using capital is $\omega^j R_{t+1}^j Q_t K_{t+1}^j$, and they have to pay a Z_{t+1}^j interest rate for their loans B_{t+1}^j . Let $\bar{\omega}^j$ be the minimum value of ω^j that allows entrepreneurs honour their debt with banks. Then:

$$\bar{\omega}^j R_{t+1}^j Q_t K_t^j = Z_{t+1}^j B_{t+1}^j \quad (8)$$

Entrepreneurs are able to honor their debt with banks only when $\omega \geq \bar{\omega}^j$. By contrast, when banks have to monitor their activities to capture all their production in order to recover the loans, incurring in a cost of $(1 - \mu)$ with $\mu \in (0, 1)$. In the latter case, the banks receive:

$$(1 - \mu) \omega^j R_{t+1}^j Q_t K_t^j \quad (9)$$

If entrepreneurs go bankrupt ($\omega < \bar{\omega}^j$), then households doubt about the ability that banks have to pay for their deposits. Let ω^{*j} be the minimum value of ω^j that allows banks to honour their debt with the depositors. When $\omega^{*j} \leq \omega \leq \bar{\omega}^j$, banks can pay their loans to depositors, even in the case that entrepreneurs can not pay their loans to banks. In the latter case, households receive:

$$(1 - \mu) \omega^{*j} R_{t+1}^k Q_t K_{t+1}^j = S_{t+1}^j D_{t+1}^j, \quad (10)$$

where S_{t+1}^j is the deposits interest rate. However, when $\omega^* \geq \omega$ then banks go bankrupt and households have to monitor the banks and capture their assets to recover the deposits, incurring a cost of $(1 - \gamma)$ with $\gamma \in (0, 1)$. In this case, households get:

$$(1 - \gamma)(1 - \mu) \omega^j R_{t+1}^j Q_t K_t^j \quad (11)$$

Now, it is possible to build up the expected income of entrepreneurs, bankers and households; considering the scenarios they have to affront. As long as $\omega^j \geq \bar{\omega}^j$, entrepreneurs' expected income is:

$$\Pi^e = \left\{ \int_{\bar{\omega}}^{\infty} \omega f(\omega) - [1 - F(\bar{\omega})] \right\} R_{t+1}^k Q_t K_{t+1} \quad (12)$$

Or in short form:

$$\Pi^e = n(\bar{\omega}) R_{t+1}^k Q_t K_{t+1} \quad (13)$$



Further, bankers face three options: if $\omega^j \geq \bar{\omega}^j$ then banks could receive the complete amount lent to entrepreneurs, including the interest rate that they charge; if $\omega^{*j} \leq \omega^j \leq \bar{\omega}^j$ then they would have to monitor the entrepreneurs and recover a fraction of their loans that would allow them to pay for the deposits that they previously received; if $\omega^j \leq \omega^{*j}$ then they would not receive any income, so then households would need to monitor the banks and recover a fraction of their deposits. Considering these possibilities, the banks' expected income can be expressed as:

$$\Pi^b = \left\{ [1 - F(\bar{\omega})]\bar{\omega} + (1 - \mu) \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega - (1 - \mu)[1 - F(\omega^*)]\omega^* \right\} R_{t+1}^k Q_t K_{t+1} \quad (14)$$

Or compactly:

$$\Pi^b = g(\omega^*, \bar{\omega}) R_{t+1}^k Q_t K_{t+1} \quad (15)$$

Finally, households could monitor banks and receive their deposits or the proportion of these derived of the monitoring process. Consequently, their expected profits are:

$$\Pi^h = \left\{ (1 - \gamma)(1 - \mu) \int_0^{\omega^*} \omega f(\omega) d(\omega) + (1 - \mu)[1 - F(\omega^*)]\omega^* \right\} R_{t+1}^k Q_t K_{t+1} \quad (16)$$

Or in a reduced way:

$$\Pi^h = h(\omega^*) R_{t+1}^k Q_t K_{t+1} \quad (17)$$

The asymmetric information among depositors, banks and entrepreneurs, results in a classic costly state verification (CSV) problem. Hence, the optimal contract is a debt contract in which the three agents interact to simultaneously to determine the level of capital and the gross interest rates of credit and deposits. The contract considers maximizing the entrepreneurs' expected profits subject to the participation constraints of bankers and depositors:

$$\begin{aligned} & \max_{\omega^*, \bar{\omega}, K} n(\bar{\omega}) R_{t+1}^k Q_t K_{t+1} \\ \text{s.t. } & g(\omega^*, \bar{\omega}) R_{t+1}^k Q_t K_{t+1} \geq R_{t+1} M_{t+1}^j \\ & h(\omega^*) R_{t+1}^k Q_t K_{t+1} \geq R_{t+1} D_{t+1}^j, \end{aligned}$$

where R_t is the gross risk-free interest rate. It is possible to substitute D from equation 3 with objective of evaluating the effects of the banking regulation in the optimal contract. Additionally, dividing the problem by (R_{t+1}) and (N_{t+1}) , it can be expressed in terms of the spread between the marginal product of capital and the risk free interest rate ($s = \frac{R_{t+1}^k}{R_{t+1}}$); the entrepreneurial leverage ($k = \frac{Q_t K_{t+1}}{N_{t+1}}$); and the ratio amongst the

net-worth of entrepreneurs and banks ($\phi = \frac{M_{t+1}}{N_{t+1}}$):

$$\begin{aligned} & \max_{\omega^*, \bar{\omega}, K} n(\bar{\omega})sk \\ \text{s.t. } & g(\omega^*, \bar{\omega})sk \geq \phi \\ & h(\omega^*)sk \geq k - 1 - \phi \end{aligned}$$

3.2.1 Liquidity regulation

To include the liquidity regulation in the model, we assume that the HQLA of the banks in each period are an exogenous fixed proportion τ of the deposits ($HQLA_{t+1} = \tau D_{t+1}$ with $\tau \in (0, 1)$). When the regulation operates the banks are forced to save this fraction in order to have enough resources available in the event that households demand their deposits during a financial distress period. It implies that, when the liquidity regulation operates, equation 7 changes by:

$$B_{t+1}^j = M_{t+1}^j + (1 - \tau)D_{t+1}^j \quad (18)$$

On the other hand, bankers may expect an outflow of a fraction of their deposits ($TECO = \phi D_{t+1}$ with $\phi \in (0, 1)$), which represents the denominator of the *LCR*: $TECO \times 0.75 \leq TECI$.

Although it is difficult to measure ϕ , the *LCR* of each country is observable, and banking balance sheets allow to have an approximation of τ , which can be calibrated as the ratio between their HQLA and their total debt. This permits to obtain a measure of ϕ .

In summary:

$$LCR = \frac{HQLA}{TECO - \min\{TECI; 75\% \text{ } TECO\}} = \frac{\tau D}{\phi D}$$

This strategy makes feasible to simulate how much have to change τ in order for a country to reach a desired level of *LCR*.

3.3 General equilibrium

Households, entrepreneurs and investors use their resources optimally; and the interaction of their choices determines the market clearing outcomes. Bankers operate as intermediaries, so the dynamics of their net worth and wealth are conditioned to the decisions of the other agents.



3.3.1 Entrepreneurs

Entrepreneurs choose the level of capital (K) and labour (L) that maximize their production returns. The technology that entrepreneurs use to transform both inputs into final goods is represented by an standard Cobb-Douglas function.

The output of all the entrepreneurs, is expressed through the aggregated production function:

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}, \quad (19)$$

where A_t is the total factor productivity, and $L_t = H_t^\Omega (H_t^e)^{\Omega_1} (H_t^b)^{1-\Omega-\Omega_1}$ given that labour come from households (H_t), entrepreneurs (H_t^e) or bankers (H_t^b). It is assumed that labour is inelastically supplied to guarantee that entrepreneurs and bankers have a positive amount of capital in each period.

Entrepreneurial wealth (V) depends on the profits they generate in each period. It is possible to obtain an expression for this variable using equations 12, 14, 16⁴:

$$V_t = R_t^k Q_{t-1} K_t - \left\{ R_t + \frac{[\mu \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega + (\mu + \gamma(1-\mu)) \int_0^{\omega^*} \omega f(\omega) d\omega] R_t^k Q_{t-1} K_t}{Q_{t-1} K_t - N_t} \right\} (Q_{t-1} K_t - N_t) \quad (20)$$

Entrepreneurial net worth (N) evolves with income, which comes from wages (W^e) and wealth (V):

$$N_{t+1} = \gamma^e V_t + W_t^e \quad (21)$$

Where γ^e is the survival entrepreneurial rate, which is introduced to ensure that entrepreneurs have to leverage their activities with banking resources. Finally, entrepreneurs who leave the market spend their wealth on consumption:

$$C_t^e = (1 - \gamma^e) V_t \quad (22)$$

3.3.2 Bankers

Similar to entrepreneurs, equations 14 and 16⁵ are used to estimate the expected benefits of the banking sector in each period, in order to derive an expression of the evolution of its wealth (V^b):

$$V_t^b = \left\{ [1 - F(\bar{\omega})] \bar{\omega} + (1 - \mu) \int_0^{\bar{\omega}} \omega f(\omega) d\omega \right\} R_t^k Q_{t-1} K_t - \left\{ R_t + \frac{\gamma(1-\mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1} K_t}{Q_{t-1} K_t - N_t - M_t} \right\} (Q_{t-1} K_t - N_t - M_t) \quad (23)$$

Again, wealth (V^b) and wages (W^b) of bankers define its net worth (M):

$$M_{t+1} = \gamma^b V_t^b + W_t^b \quad (24)$$

⁴See Derivation of Wealth Equations for the procedure.

⁵See Derivation of Wealth Equations for details.

Where γ^b is the banking survival rate, so the consumption of the banking sector is given by:

$$C_t^b = (1 - \gamma^b)V_t^b \quad (25)$$

3.3.3 Investors

Investors produce and rent capital to entrepreneurs. Their accumulation of capital, depends on adjustment costs $\left(\Phi\left(\frac{I_t}{K_t}\right)K_t\right)$, and the depreciation rate (δ):

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right)K_t + (1 - \delta)K_t \quad (26)$$

The price Q that entrepreneurs pay for renting capital, is a function of the adjustment costs:

$$Q_t = \frac{1}{\Phi'\left(\frac{I_t}{K_t}\right)K_t} \quad (27)$$

3.3.4 Households

There is a continuum of households of length unity. Families maximize their utilities, which are concave, positively related to consumption (C) and negatively related to work (H). The optimization problem is subject to the inter-temporal budget constraint, which guarantees that the income obtained by households from wages (S) and deposits (D), does not exceed what they expend on consumption. That is:

$$\begin{aligned} \max_{C,H,D} \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k [\log C_{t+k}^h + \xi \log(1 - H_{t+k})] \\ \text{s.t. } C_{t+k}^h = W_{t+k}H_{t+k} + R_{t+k}^d D_{t+k} - D_{t+k+1} \end{aligned}$$

Where R_t^d is the interest rate of the deposits, which is composed of the risk-free interest rate (R_t), plus the spread $\left(\frac{\gamma(1-\mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1} K_t}{Q_{t-1} K_t - N_t - M_t}\right)$ that households charge to banks as a compensation for the risk of bankruptcy of the latter.

3.4 Calibration

We calibrate our model for a representative economy by using standard parameter values taken from the existing literature. Specifically, Table 4 shows that values of the subjective discount factor (β), capital depreciation rate (δ), capital share in production (α), and the elasticity price of capital (Φ) were taken from [Bernanke et al., 1999].



Moreover, the baseline value for the monitoring cost of banks (μ) was set to 0.2 as in [Carlstrom and Fuerst, 1997]. For simplicity, we set the monitoring cost of households (γ) to be equal to the monitoring cost of banks. On top of that, since we are interested in making comparative static exercises in steady state by means of changing the values of the monitoring costs, i.e. different degrees of financial development, we set the variance of the idiosyncratic productivity shocks distribution to 1.2 in order to ensure the model solution for a wide range of values of μ . Such a value, however, is a bit higher than that reported in the literature, which lies between 0.2 and 0.3⁶.

On the other hand, we assume that labour supply of entrepreneurs (H^e) and bankers (H^b) are perfectly inelastic, in the spirit of [Bernanke et al. (1999)]. Entrepreneurs and bankers' labor supply was normalized to unity, and their importance in the output was fixed to 0.01, trying to avoid changes in results due to their existence, as was proposed in Bernanke et al. (1999). Moreover, we set the survival rate of banks (γ^b) to 0.97 as in Gertler and Karadi (2011), and the survival rate of entrepreneurs (γ^e) to 0.80 according to the Bureau of Labor Statistics BLS (2016).

Description	Parameter	Value ⁵	Source
Subjective discount factor	β	0.99	[Bernanke et al., 1999]
Depreciation rate	δ	0.025	[Bernanke et al., 1999]
Capital share in production	α	0.35	[Bernanke et al., 1999]
Labour share in production	$1 - \alpha$	0.7	[Bernanke et al., 1999]
Labour share of Households	Ω	0.98	[Bernanke et al., 1999]
Labour share of Entrepreneurs	Ω_1	0.01	[Bernanke et al., 1999]
Elasticity of the price of capital	Φ	0.1	[Bernanke et al., 1999]
Labour force of Entrepreneurs	H^e	1	[Bernanke et al., 1999]
Labour force of Banks	H^b	1	[Bernanke et al., 1999]
Monitoring costs of banks	μ	0.2	[Carlstrom and Fuerst]
Variance of the ω distribution	$\text{Var}(\omega)$	1.2	Ensures model solution
Survival rate of Banks	γ^b	0.97	[Gertler and Karadi, 2011]
Survival rate of Entrepreneurs	γ^e	0.8	[BLS, 2016]
Expected fraction of deposits claimed by households	ϕ	0.03	[BIS, 2013]

Table 4: Model calibration

Notice that to implement the regulation in the model there are two critical parameters that need to be calibrated (following equation 18⁷): the expected fraction of deposits claimed by households within the next 30 day period (ϕ), and the fraction of the deposits that bankers must save (τ) in order to comply with the regulation. According to the Bank of International Settlements BIS (2013), the expected outflows on certain types of fully insured retail deposits in the LCR regulation permanently

⁶See Bernanke et al. (1999), Christiano et al. (2014), among others.

⁷See Section 3.2.1 for more details

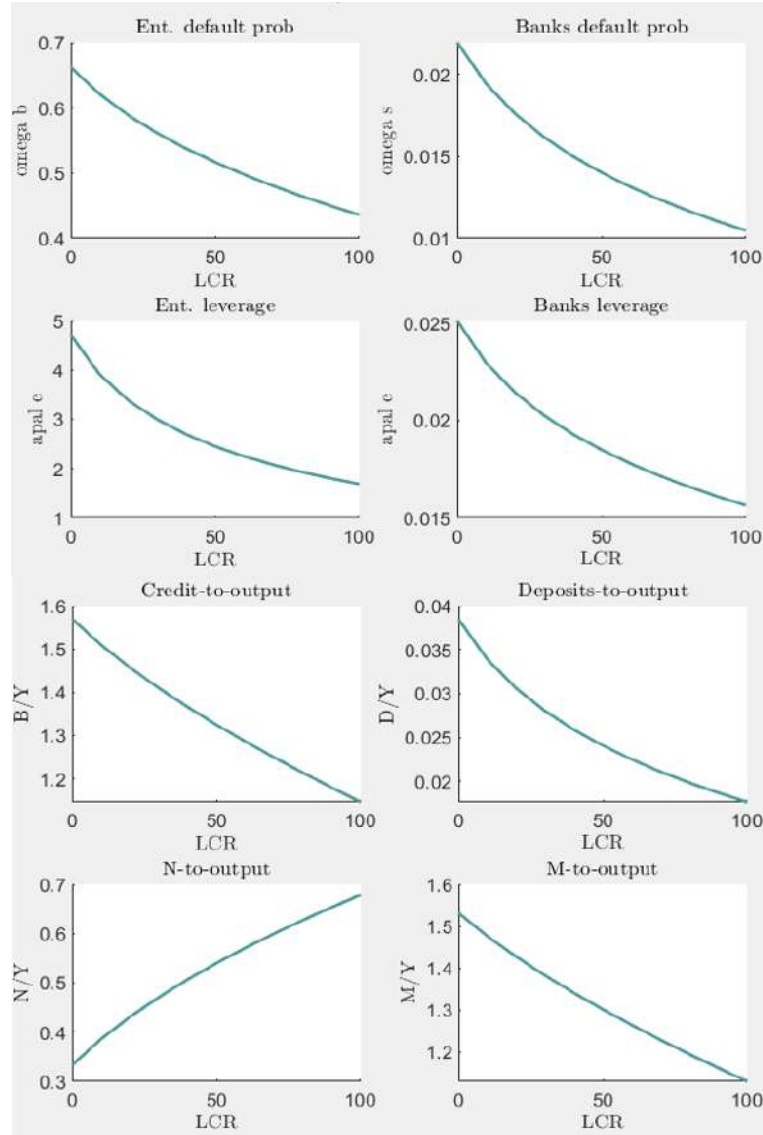


Figure 5: Long-run effects of LCR on financial stability and credit.

changed from 5% to 3% in January 2013. Therefore, we set $\phi = 0.03$, such that τ will adjust to any possible value of the LCR, where the latter will range from 0% to 100% in the model simulations.

3.5 Results

What are the theoretical predictions of the macroeconomic model about the effects of the LCR on financial stability and credit? What are the theoretical effects of the LCR on the economy? To understand the model's responses to this questions, it is important to remember that it has two groups of variables: first, those related to the banking system, which are captured in the Contract. Second, those associated to the real sector of the economy.



3.5.1 Long-run effects of LCR on financial stability and credit

Our empirical findings suggest that the LCR policy has improved financial stability, although its effect on credit-to-output ratio is not clear. According to the macroeconomic model, figure 5 shows that the LCR policy is predicted to have positive long-run effects on financial stability as the bankruptcy rate probability for both entrepreneurs ($\bar{\omega}$) and banks (ω^*) fall down. This result is consistent to the negative long-run responses of entrepreneurial and bank leverages to the LCR, which in turn reflects a better allocation of risks.

On the other hand, the ambiguity observed in our empirical findings regarding the effects of the LCR on credit-to-output ratio, can be rationalized by our macroeconomic model. Through its lens, such an ambiguity can be understood as the realization of two possible outcomes. First, if banks would like to keep credit flowing to entrepreneurs, then it needs to be willing to raise deposits in order to comply with a greater LCR requirement. A second possibility is that banks use a lower percentage of their deposits to comply with the increasing LCR policy, however, in that case banks would be required to diminish credit to the entrepreneurs as banks would have less available resources to lend. According to figure 5, credit-to-output ratio falls down as the LCR requirement increases, which reflects the dominance of the latter channel: banks consider that using less available resources from deposits is a better choice, inducing a fall in credit-to-output ratio as an optimal response.

Figure A.4 represents graphically the theoretical effects of the LCR policy on credit. As the *LCR* regulation forces banks to keep a fraction τ of their deposits saved, then it prevents banks to use their total amount of deposits, such that an increase in the *LCR* will decrease the banks' availability of deposits *for any value of the deposits interest rate*. Thus, the *LCR* shock triggers a downward-left shift in the banks' demand curve for deposits. Given that the household's supply curve of deposits doesn't change, it is worth noting that the contraction in the banks' deposits demand curve translates into lower deposits quantities in equilibrium. In turn, lower equilibrium deposits make banks to have less available resources to lend to the entrepreneurs *for any value of the credit interest rate*. Everything else equal, this can be represented by an upward-left shift in the banks' credit supply curve. Given that the entrepreneurs' credit demand curve doesn't change, then the amount of credit falls down in equilibrium.

Interestingly, figure 5 shows that entrepreneurial net-worth, as percentage of output, increases with the LCR requirement, which is part of the better allocation of resources induced by the LCR policy: given that banks optimally lower lending, then entrepreneurs choose to increase their own resources to finance their investment projects, implying lower entrepreneurial leverage. In turn, the lesser banks' demand for deposits reduces banking leverage, which improves financial stability. Moreover, the lower credit

reduces banks profits, which translates into lesser banks net-worth to output ratio.

3.5.2 Macro-effects trade off? The role of heterogeneous financial frictions

What are the long-run macroeconomic effects of having implemented the LCR policy? In this subsection we argue that a trade-off between LCR regulation and long-term macro performance, i. e. investment, consumption and output in steady state, may arise, depending on the degree of financial development, which is captured here by the monitoring (agency) costs.

Indeed, we hypothesize that countries that are more financially developed are prone to be richer economies, while those countries with lower financial development are likely to be less developed ones. Figure 6 proves that such a hypothesis makes sense in the data as it shows that economies that are more developed (Advanced Economies) correspond to countries with higher degrees of financial development, e. g. the International Monetary Fund's (IMF's) Financial Development index is higher on average. On the other hand, figure 6 shows that developing countries (Emerging Markets) are related to lower financial development, e.g. the IMF's financial development index is lower on average. In regards of the macroeconomic model, figure 7 shows that the greater the agency costs (less financially developed economies), then the lower the long-term (steady state) values of investment, output and consumption.

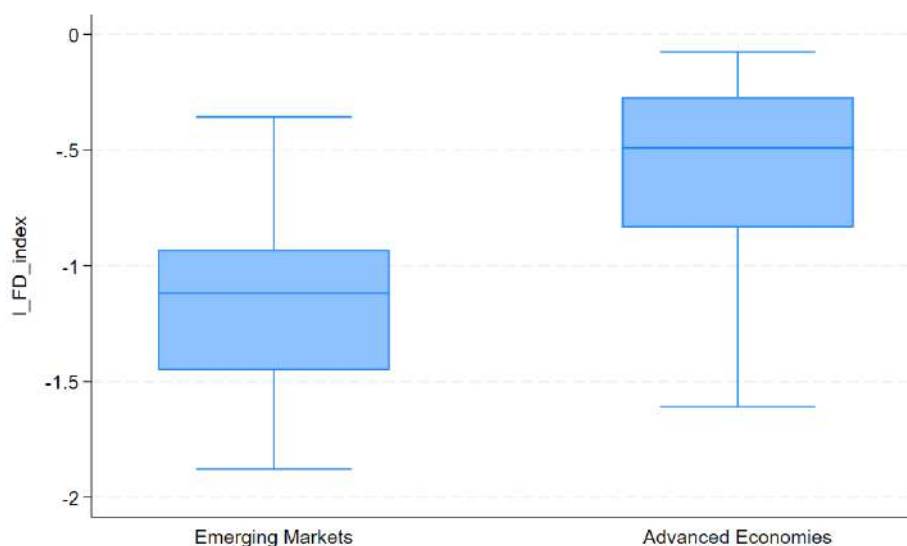


Figure 6: Financial development in emerging and advanced market economies

Moreover, figure 7 shows that the long-run effects of implementing the LCR depend on the values that the agency cost parameters (μ, γ) take. For instance, panel (a) in figure 7 shows that, when $\mu = \gamma = 0.20$, the LCR has long-term negative effects on investment, output and consumption. This means that those countries with higher

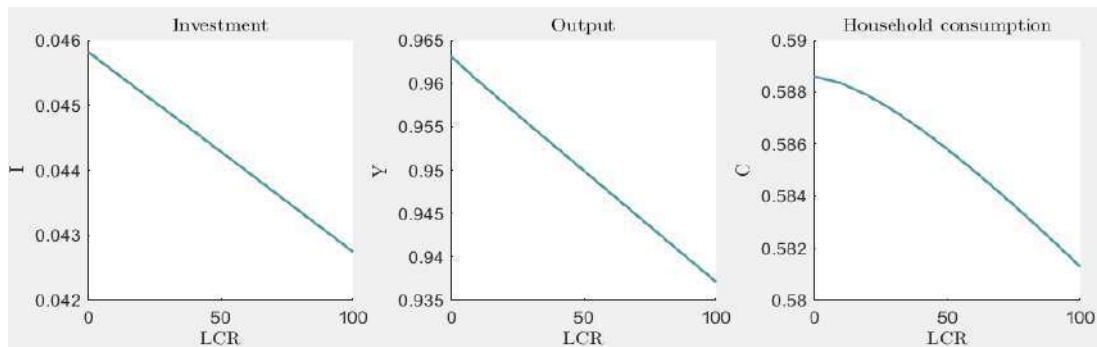
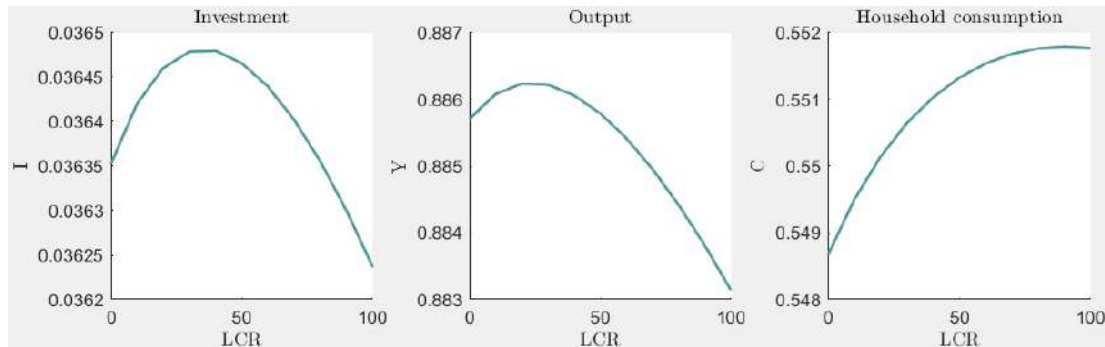
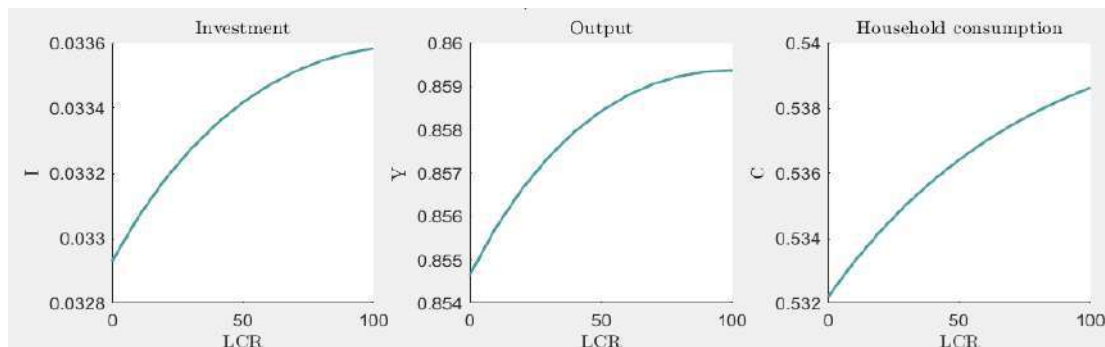

 (a) $\mu = \gamma = 0.20$

 (b) $\mu = \gamma = 0.25$

 (c) $\mu = \gamma = 0.28$

 Figure 7: Long-run (steady state) macro effects of LCR, for different values of $\mu = \gamma$.

financial development (lower monitoring costs) may experience a trade-off between financial stability and long-run macro performance. Such a trade-off starts to disappear as $\mu = \gamma$ increases: while panel (b), which corresponds to $\mu = \gamma = 0.25$, exhibits a non-linear relationship between LCR and long-run macro performance, panel (c) conveys a positive relationship between implementing the LCR and macro performance. Importantly, although the effect of the LCR on macro performance depends on the degree of financial frictions, the effect of the LCR on the long-term financial variables doesn't change with the financial frictions, and their behavior is similar to those observed for the case $\mu = \gamma = 0.20$ that is highlighted in figure 5.

What is behind the heterogenous responses of the macro performance as the agency costs change? to answer this question it is convenient to examine figure 8, which

exhibits the smooth optimal transitions between the steady values of the model when banks adopt $LCR = 100\%$ in comparison to an economy with no liquidity regulation ($LCR=0$), for two different levels of $\mu = \gamma$, say 0.2 (blue color) and 0.28 (red color). It shows that in economies with greater financial frictions, i. e. higher agency costs, both credit and credit-to-output ratio are lower in steady state. Therefore, economies with greater financial frictions have lower entrepreneurial and banking leverage, which in turn puts pressure on entrepreneurs to have greater net-worth in steady state, in comparison to economies with lower financial frictions. As a result, even though economies with greater financial frictions have lower investment in steady state, the latter increases with LCR because net-worth starts to weight more in the entrepreneur's investment projects in comparison to the weight of credit, as the financial market gets less financially developed. Hence, the responses of long-run investment and output to the LCR become positive as the agency costs increase. As a consequence, long-run consumption also starts to react positively to the LCR as financial frictions tighten.

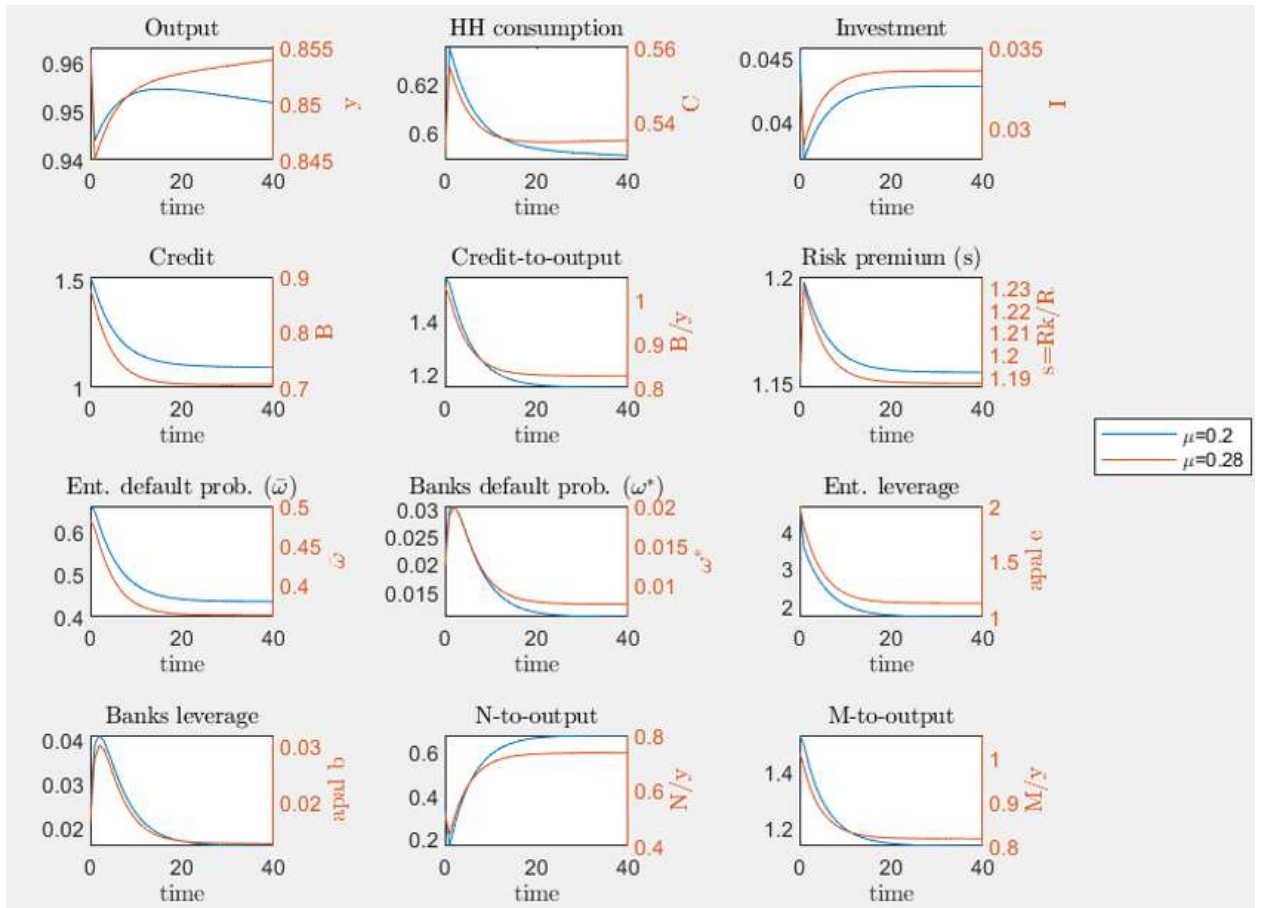


Figure 8: Smooth optimal transitions between steady states (LCR=0% vs LCR=100%), for different values of agency costs.



3.5.3 Aggregate shocks: The role of LCR along the business cycle

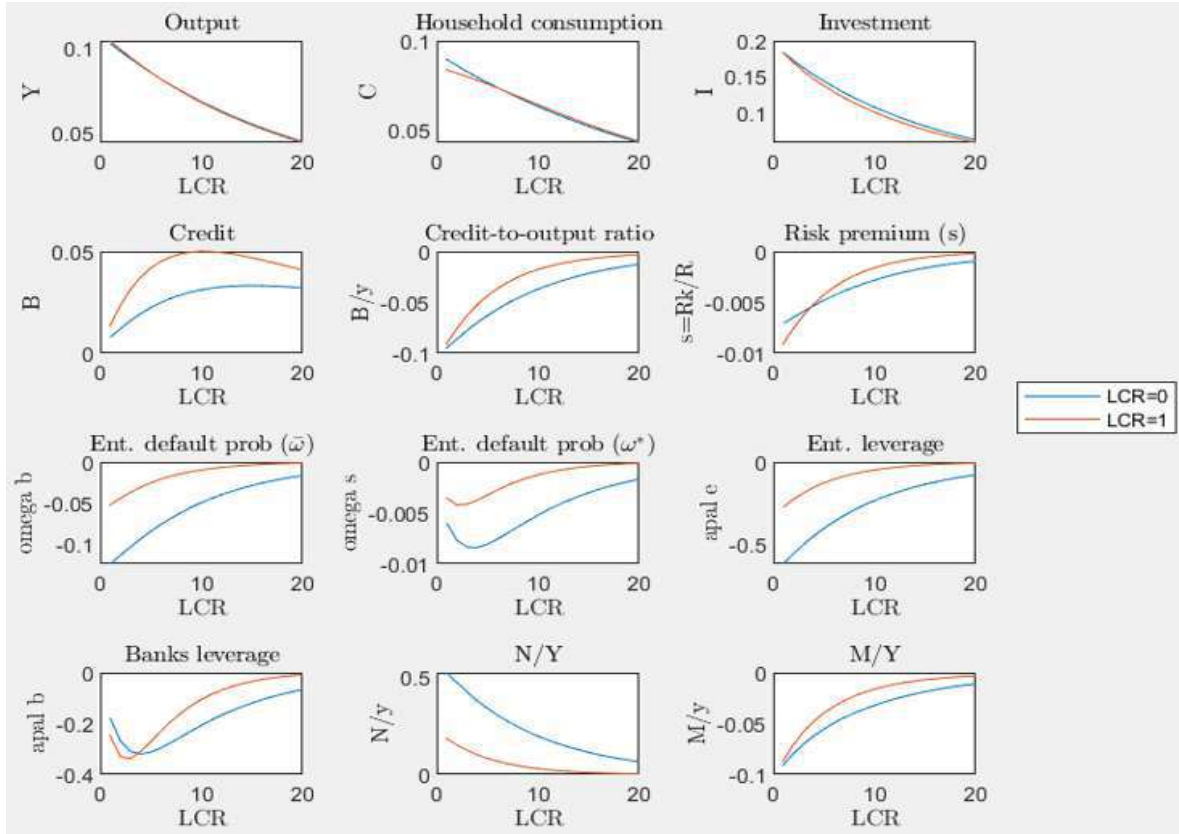
A natural question that arises is whether the LCR may have effects along the business cycle. Specifically, we ask the macro model for the possibility that implementation of the LCR requirements may have effects on the cyclical volatility of the economy. At this respect, figure 9 shows the impulse responses of the macro model when the economy is hit by a transitory, positive 1% productivity shock regarding its steady state value. The figure presents impulse response functions as percentage deviations from the steady state, with (LCR=100%) and without (LCR=0%) having implemented the liquidity regulation, for different degrees of financial frictions.

Figure 9 shows that, regardless of the agency costs parameter values, the economy is generally less volatile along the business cycle when the LCR policy is implemented. In particular, while the macro variables (output, investment and household consumption) performance is a little bit less volatile (specially investment) when the economy adopts the LCR, the lower volatility is much clearer in the financial side. For instance, countercyclical default probabilities for entrepreneurs and banks, which are proportional to $\bar{\omega}$ and ω^* , respectively, fall down in a less intense way when the economy works with the liquidity regulation. Lower volatility is also observed in the case of entrepreneurial and banking leverages, risk premium ($s = R^k/R$), credit-to-output and net-worth-to-output ratios. In sum, the macro model predicts that, regardless of the degree of financial frictions, implementing the LCR improves financial stability in the long-run and lowers cyclical volatility in the short-run, especially the financial variables.

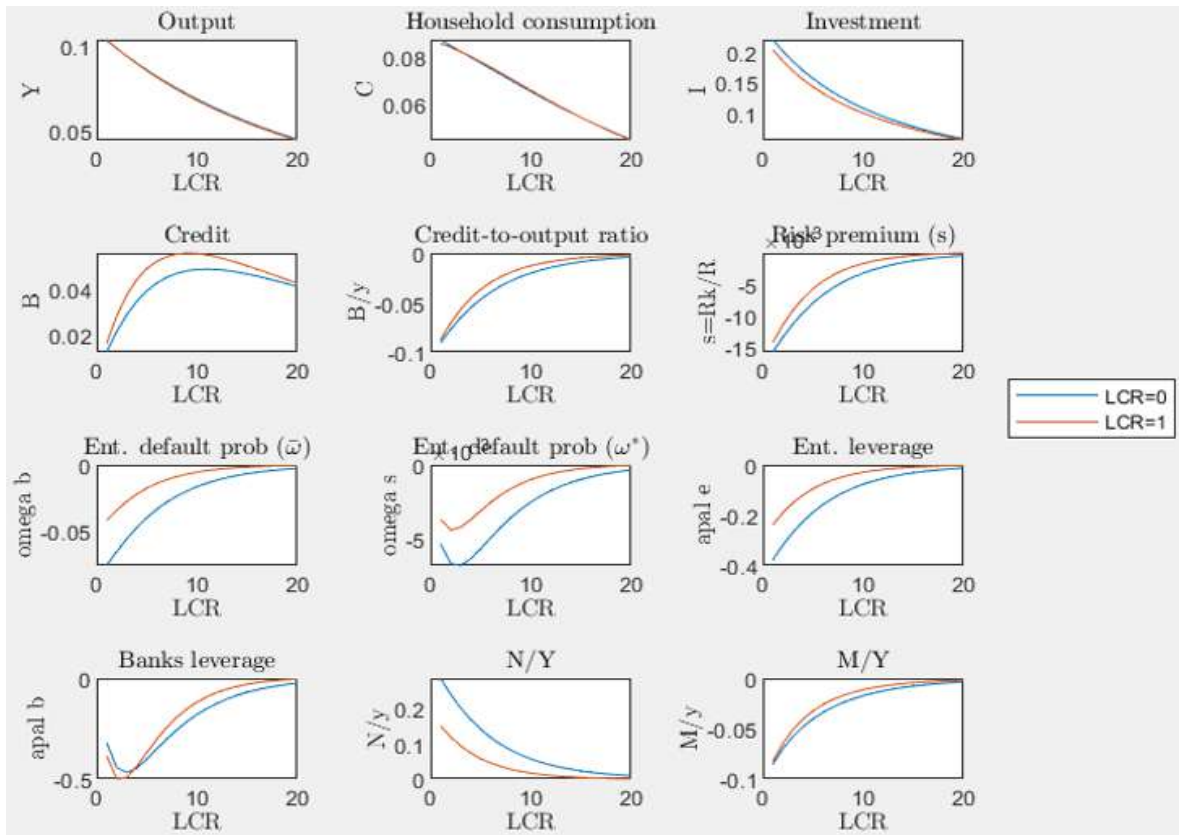
4 Conclusions

We have presented comprehensive evidence that the adoption of Basel-type liquidity requirements has helped countries build more robust and stable banking systems. Additionally, we have developed an equilibrium model that: (i) can replicate this result by endogenously limiting banks' excessive risk-taking, (ii) allows us to make sense of the conflicting evidence on the impact that such requirements may have on lending, and (iii) helps us better understand the aggregate consequences of enforcing these financial standards.

Our results show that liquidity requirements may have quite different macroeconomic implications for countries with different degrees of financial development (captured by agency problems). This suggests that one-size-fits-all requirements (such as a LCR of 100%) may be suboptimal for certain countries. Future revisions of the Basel standards could benefit from a more granular analysis that can help design contingent rules, all of which in turn can be viewed as a promising avenue for future research.



(a) $\mu = \gamma = 0.20$



(b) $\mu = \gamma = 0.28$

Figure 9: Role of LCR along the business cycle, for different values of $\mu = \gamma$.



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A Appendix

A.1 The Liquidity Coverage Ratio (LCR)

Basel III seek to improve the banking and financial stability through the implementation of a set of new or modified regulations pretending to mitigate the bank risk-taking. The most studied regulations in this sense are the capital requirements and the liquidity requirements. Due the aim of this work, we will concentrate in to characterize the LCR regulation and its implementation, using in the last case a set of developed and emerging countries as reference.

The LCR is defined as the coefficient between high quality liquid assets (HQLA, hereafter) and total net outflows over the next 30 calendar days. In this way, this index measures the percentage of resources that each bank has to account for debts due in a month or sooner, and captures the vulnerability of each bank in the presence of a banking run. The Basel III Accord pretends that all banks reach a LCR of 100% or higher, proposing a path of implementation from 2013-2019, as Table A.1 shows.

	1 January 2015	1 January 2016	1 January 2017	1 January 2018	1 January 2019
Minimum LCR	60%	70%	80%	90%	100%

Table A.1: LCR implementation

Formally, the LCR is calculated as the HQLA over Total Expected Cash Outflows (TECO, hereafter) minus the minimum between 75% of the TECO and the Total Expected Cash Inflows (TECI, hereafter); over a 30-day period:

$$LCR = \frac{HQLA}{TECO - \min\{TECI; 75\% \text{ } TECO\}}$$

While the measures of *TECO* and *TECI* correspond with the deposits, portfolio and credit characteristics of each bank, Basel III committee establishes a normative on the classification and the weights of the *HQLA*⁸, which are summarized in Table A.2:

⁸Visit <https://www.bis.org/publ/bcbs238.pdf> for detailed information.



<i>HQLA 1</i>	<i>HQLA 2A (-15%)</i>	<i>HQLA 2B (-25% to -50%)</i>
Coins and banknotes	20% risk Marketable securities	Residential mortgage backed securities
Central bank reserves	Corporate debt securities ($\geq$ AA-)	Corporate debt securities (A+ to BBB-)
Sovereign or Central bank debt	Covered bonds	Common equity shares
0% risk Marketable securities		

Table A.2: Classification of *HQLA*

A.2 Stationarity tests

To verify the stationarity of the variables included in the econometric models, panel unit root tests were conducted for Credit-to-GDP and the logarithm of the Z-Score. Both Im, Pesaran, and Shin (IPS) and Fisher-type tests were performed. These tests allow for unbalanced panels and assess the non-stationarity of the aggregated panel data.

Test	Test Statistic	p-value	Null Hypothesis
Variable in Levels (credit_gdp)			
Im-Pesaran-Shin (IPS)	0.2251	0.5891	Unit root in all panels
Fisher ADF (Inverse chi-squared)	161.0857	0.5497	Unit root in all panels
Fisher ADF (Modified inv. chi-squared)	-0.1609	0.5639	Unit root in all panels
Variable in First Differences (D.credit_gdp)			
Im-Pesaran-Shin (IPS)	-19.2952	0.0000	Unit root in all panels
Fisher ADF (Inverse chi-squared)	544.7680	0.0000	Unit root in all panels
Fisher ADF (Modified inv. chi-squared)	21.0244	0.0000	Unit root in all panels
Variable in Levels (ln_BankZscore)			
Im-Pesaran-Shin (IPS)	-7.6195	0.0000	Unit root in all panels
Fisher ADF (Inverse chi-squared)	299.1521	0.0000	Unit root in all panels
Fisher ADF (Modified inv. chi-squared)	7.9404	0.0000	Unit root in all panels

Table A.3: Panel Unit Root Test Results

For Credit-to-GDP, the results indicate the presence of a unit root in levels across all countries. However, when taking the first difference, there is evidence of stationarity. In contrast, for the financial stability measure ($\ln BankZscore$), the results suggest stationarity in levels, meaning that no transformation is necessary.

A.3 Derivation of Wealth Equations

The wealth of entrepreneurs can be obtained, considering that the constraints of the contract that guarantees the participation of bankers and depositors, should be bind-

ing.

We know that the expected profits of bankers should be equal at their opportunity cost:

$$[1 - F(\bar{\omega})]\bar{\omega}R_t^k Q_{t-1}K_t = R_t M_{t+1} + (1 - \mu)[1 - F(\omega^*)]\omega^* R_t^k Q_{t-1}K_t - (1 - \mu) \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t \quad (\text{A.1})$$

This condition is symmetrical for the depositors:

$$(1 - \mu)[1 - F(\omega^*)]\omega^* R_t^k Q_{t-1}K_t = R_t(Q_{t-1}K_t - N_t - M_t) - (1 - \gamma)(1 - \mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t \quad (\text{A.2})$$

From both expressions we find that:

$$[1 - F(\bar{\omega})]\bar{\omega}R_t^k Q_{t-1}K_t = R_t(Q_{t-1}K_t - N_t) - \left[(1 - \mu) \int_0^{\bar{\omega}} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t - \gamma(1 - \mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t \right] \quad (\text{A.3})$$

Substituting equation A.3 in the expected profits of the entrepreneurs, it is possible to write:

$$\Pi^e = R_{t+1}^k Q_t K_{t+1} - R_t(Q_{t-1}K_t - N_t) - \mu \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t - [\mu + \gamma(1 - \mu)] \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t \quad (\text{A.4})$$

From this expression we derive the equation of entrepreneurial wealth:

$$V_t = R_t^k Q_{t-1}K_t - \left\{ R_t + \frac{\mu \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega + [\mu + \gamma(1 - \mu)] \int_0^{\omega^*} \omega f(\omega) d\omega}{(Q_{t-1}K_t - N_t)} \right\} (Q_{t-1}K_t - N_t) \quad (\text{A.5})$$

To obtain the equation of banking wealth, we start with the expected profits of the bankers:

$$\Pi^b = \left\{ [1 - F(\bar{\omega})]\bar{\omega} + (1 - \mu) \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega - (1 - \mu)[1 - F(\omega^*)]\omega^* \right\} R_{t+1}^k Q_t K_{t+1} \quad (\text{A.6})$$

Given that the expected profits of the depositors are binding, we can equate equation 14 with equation 16 to get:

$$\Pi^b = [1 - F(\bar{\omega})]\bar{\omega}R_t^k Q_{t-1}K_t + (1 - \mu) \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t + (1 - \gamma)(1 - \mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t - R_t(Q_{t-1}K_t - N_t - M_t) \quad (\text{A.7})$$

Which can be rewritten as:

$$V_t^b = \left\{ [1 - F(\bar{\omega})]\bar{\omega} + (1 - \mu) \int_0^{\bar{\omega}} \omega f(\omega) d\omega \right\} R_t^k Q_{t-1}K_t - \left\{ R_t + \frac{\gamma(1 - \mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_t^k Q_{t-1}K_t}{Q_{t-1}K_t - N_t - M_t} \right\} (Q_{t-1}K_t - N_t - M_t) \quad (\text{A.8})$$



A.4 Equations of the Model

The equations to solve the entire model are presented in this section:

$$s_{ss} = \frac{1}{(1-\tau)} \left\{ \frac{n_{\bar{\omega}}(\bar{\omega})g_{\omega^*}(\omega^*, \bar{\omega})}{n(\bar{\omega})g_{\bar{\omega}}(\omega^*, \bar{\omega})h_{\omega^*}(\omega^*) - n_{\bar{\omega}}(\bar{\omega})g(\omega^*, \bar{\omega})h_{\omega^*}(\omega^*) + n_{\bar{\omega}}(\bar{\omega})g_{\omega^*}(\omega^*, \bar{\omega})h(\omega^*)} \right\} \quad (\text{A.9})$$

$$s_{ss} = \frac{1}{(1-\tau)h(\omega^*)k_{ss}} [k_{ss} - 1 - \phi] \quad (\text{A.10})$$

$$k_{ss} = \frac{\phi}{s_{ss}g(\omega^*, \bar{\omega})} \quad (\text{A.11})$$

$$Y_{ss} = K_{ss}^\alpha \left[H_{ss}^\Omega (H_{ss}^e)^{\Omega_1} (H_{ss}^b)^{1-\Omega-\Omega_1} \right]^{1-\alpha} \quad (\text{A.12})$$

$$R_{ss}^k = \alpha \frac{Y_{ss}}{K_{ss}} + (1-\delta) \quad (\text{A.13})$$

$$s_{ss} = \frac{R_{ss}^k}{R_{ss}} \quad (\text{A.14})$$

$$R_{ss}^d = \frac{R_{ss}[1 + \gamma(1-\mu) \int_0^{\omega^*} \omega f(\omega) d\omega s_{ss} Q_{ss} K_{ss}]}{Q_{ss} K_{ss} - N_{ss} - M_{ss}} \quad (\text{A.15})$$

$$R_{ss}^b = R_{ss} + \frac{\mu \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega + [\mu + \gamma(1-\mu)] \int_0^{\omega^*} \omega f(\omega) d\omega R_{ss}^k Q_{ss} K_{ss}}{Q_{ss} K_{ss} - N_{ss}} \quad (\text{A.16})$$

$$V_{ss}^b = \left\{ [1 - F(\bar{\omega})] \bar{\omega} + (1-\mu) \int_0^{\bar{\omega}} \omega f(\omega) d\omega \right\} R_{ss}^k Q_{ss} K_{ss} - \left\{ R_{ss} + \frac{\gamma(1-\mu) \int_0^{\omega^*} \omega f(\omega) d\omega R_{ss}^k Q_{ss} K_{ss}}{Q_{ss} K_{ss} - N_{ss} - M_{ss}} \right\} (Q_{ss} K_{ss} - N_{ss} - M_{ss}) \quad (\text{A.17})$$

$$W_{ss}^b = (1-\alpha)(1-\Omega-\Omega_1) \frac{Y_{ss}}{H_{ss}^b} \quad (\text{A.18})$$

$$M_{ss} = \gamma^b V_{ss}^b + W_{ss}^b \quad (\text{A.19})$$

$$C_{ss}^b = (1-\gamma^b) V_{ss}^b \quad (\text{A.20})$$

$$V_{ss} = R_{ss}^k Q_{ss} K_{ss} - \left\{ R_{ss} + \frac{\mu \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega + [\mu + \gamma(1-\mu)] \int_0^{\omega^*} \omega f(\omega) d\omega}{(Q_{ss} K_{ss} - N_{ss})} \right\} (Q_{ss} K_{ss} - N_{ss}) \quad (\text{A.21})$$

$$W_{ss}^e = (1 - \alpha)\Omega_1 \frac{Y_{ss}}{H_{ss}^e} \quad (\text{A.22})$$

$$N_{ss} = \gamma^e V_{ss} + W_{ss}^e \quad (\text{A.23})$$

$$C_{ss}^e = (1 - \gamma^e) V_{ss} \quad (\text{A.24})$$

$$W_{ss} = (1 - \alpha)\Omega \frac{Y_{ss}}{H_{ss}} \quad (\text{A.25})$$

$$I_{ss} = \left[\frac{\delta}{\theta} \right]^{\frac{1}{\alpha_1}} K_{ss} \quad (\text{A.26})$$

$$C_{ss} = Y_{ss} - I_{ss} - C_{ss}^e - C_{ss}^b - \mu \int_{\omega^*}^{\bar{\omega}} \omega f(\omega) d\omega - [\mu + \gamma(1 - \mu)] \int_0^{\omega^*} \omega f(\omega) d\omega \quad (\text{A.27})$$

$$B_{ss} = Q_{ss} - N_{ss} \quad (\text{A.28})$$

$$(1 - \tau)D_{ss} = Q_{ss}K_{ss} - N_{ss} - M_{ss} \quad (\text{A.29})$$



A.5 List of countries and liquidity requirements implementation dates

Advanced Economies	Implementation	Emerging Economies	Implementation
United Arab Emirates	2016	Albania	N.I.
Australia	2015	Argentina	2015
Austria	2015	Armenia	N.I.
Belgium	2017	Azerbaijan	N.I.
Bahrain	N.I.	Bulgaria	2015
Canada	2015	Belarus	2018
Switzerland	2015	Brazil	2015
Chile	2016	Botswana	N.I.
Cyprus	2015	China	2014
Germany	2015	Colombia	2009
Denmark	2015	Costa Rica	2015
Spain	2015	Dominican Republic	N.I.
Estonia	2015	Ecuador	N.I.
Finland	2015	Fiji	N.I.
France	2015	Georgia	2017
United Kingdom	2015	Jamaica	2019
Greece	2015	Jordan	N.I.
Hong Kong SAR	2015	Kazakhstan	2018
Croatia	2015	Moldova	N.I.
Hungary	2015	Mexico	2015
Ireland	2015	North Macedonia	N.I.
Iceland	2013	Mauritius	2017
Israel	2015	Malaysia	2015
Italy	2015	Peru	2014
Japan	2015	Paraguay	N.I.
Korea, Rep.	2015	Russian Federation	2016
Kuwait	2016	Serbia	2017
Lithuania	2015	Thailand	2016
Luxembourg	2015	South Africa	2015
Latvia	2015		
Malta	2015		
Netherlands	2015		
Norway	2015		
New Zealand	N.I.		
Oman	2015		
Poland	2015		
Portugal	2015		
Romania	2015		
Saudi Arabia	2015		
Singapore	2015		
Slovak Republic	2004		
Slovenia	N.I.		
Sweden	2013		
Uruguay	2015		
United States	2015		

Figure A.1: List of countries and implementation dates

A.6 Time patterns of liquidity requirements implementation

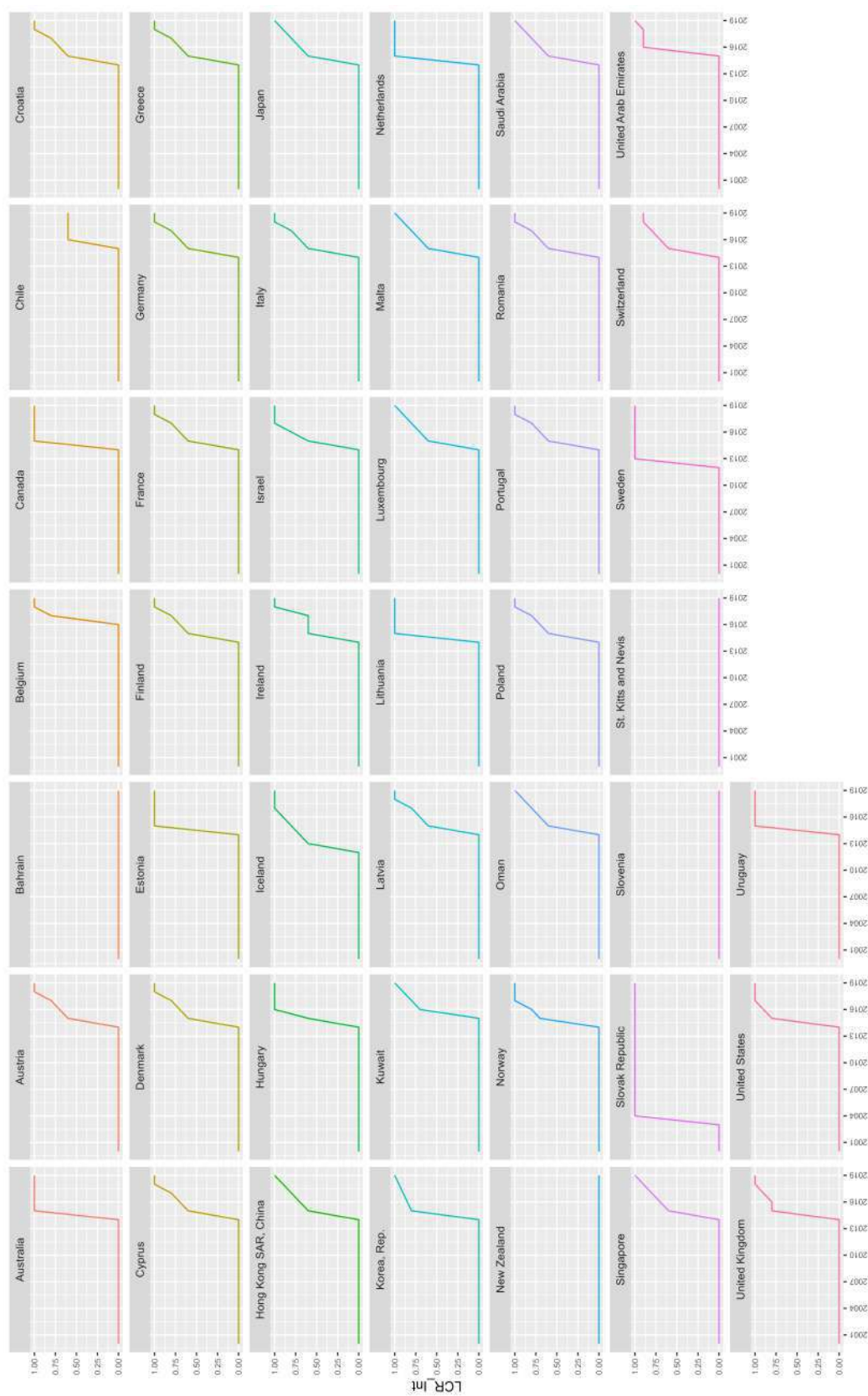


Figure A.2: Treatment variable dynamics in DM

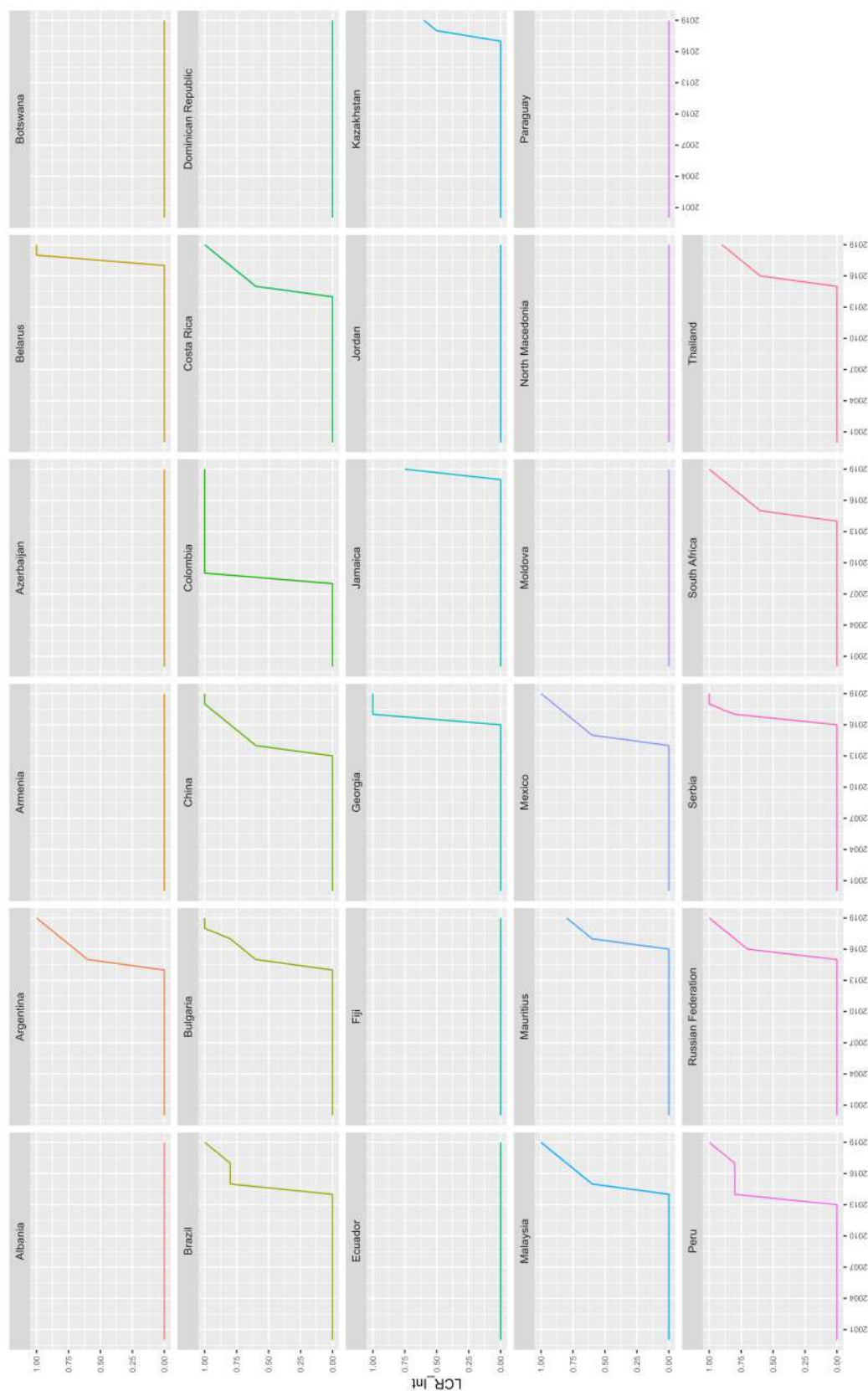
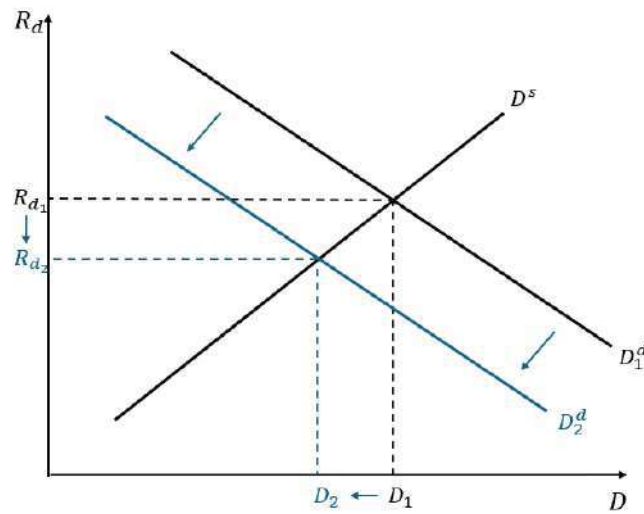
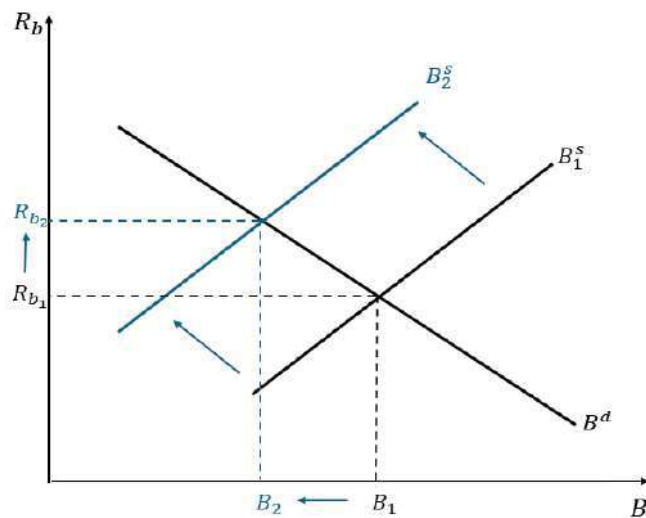


Figure A.3: Treatment variable dynamics in EM

A.7 Theoretical effects of the LCR on deposits and credit markets



(a) Deposits market.



(b) Credit market.

Figure A.4: *LCR* shock on deposits and credit markets.



**Mejor Tesis de Maestría
en Economía y Finanzas**

Juan Camilo Pájaro Gallego

*A model of the Lingering Use of
Cash: Infección, Accessibility,
and Acceptability*

**Aso
Ban
Caria**

90 Años
Acercando la
Banca a los
Colombianos

Master Thesis

Juan Camilo Pájaro Gallego¹

A Model of the Lingering Use of Cash: Infection, Accessibility, and Acceptability

Abstract

Although technological innovations have eased the shift from cash to digital and electronic payments, cash remains as a prominent payment method, particularly in developing economies. I contribute to the understanding of why a sizeable segment of the population continues to rely on cash by studying the choice of payment method. In this paper, I focus on three key attributes: acceptability, accessibility, and, as a novelty, disutility costs related to infection through viruses. Thus, the objective is to develop a theoretical model, based on the New Monetarist approach, for answering under what circumstances might cash, with its advantages in acceptability and no access costs but drawbacks in disutility cost, be preferred over electronic money? The model finds that despite heightened risks of virus and bacteria transmission related to the cash usage and the growing acceptance of e-money, buyers may not necessarily abandon cash to switch to e-money. It depends on the capacity of each buyer to afford the access cost and each seller to invest in the technology required for transitioning to e-money. In some equilibria, cash exhibits a lingering use, meaning it remains as a preferred payment method for lower-class buyers, and most accepted method by smaller-sized sellers. Policy recommendation is aimed at reducing the high fees or costs of access faced by buyers and sellers in the financial system to be able to use electronic payment methods, which in turn improves financial inclusion.

Keywords: cash, e-money, infection, access costs, acceptability, payment methods, search theory.

JEL: D83, E40, E41, I10.

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1 Introduction

«Perhaps hard cash will always find a niche, tucked away in children's birthday cards and as money for the unbanked and phoneless».

The Economist, February 15th, 2007a.

On February 15th, 2007, The Economist predicted that over the following 15 years cash might gradually melt away driven by technological innovations such as smartphones enabling money transfers and cards facilitating transactions without a signature or PIN number (The Economist, 2007a). Nowadays, though these technological advancements have eased the shift from cash to digital and electronic methods, the prediction fell short, and cash remains as a prominent payment method, particularly in developing countries.

It is worth noting that the Covid-19 pandemic in 2020 accelerated the adoption of digital and contactless payment methods due to the social distancing and hygiene concerns. However, cash is still used by a sizeable part of the population. According to the Global Findex Database (World Bank, 2021), globally, 620 million adult account holders made utility bill payments using cash. Conversely, in developing countries 1.6 billion adults with accounts used only cash for seller payments. That is, excluding China for developing countries, the survey suggests that two-thirds of adults with accounts exclusively used cash for merchant payments. The Global Payments Report (FIS Global, 2023) indicates that in Latin America in 2022, cash represented the primary point-of-sale (POS) payment method at 31%, followed closely by credit cards at 30%, debit cards at 24%, and digital wallets at 15%. Their projections suggest that by 2026, cash will account over one-fifth of the total value of regional POS transactions.

In this paper, I contribute to the understanding of why a considerable segment of the population continues to rely on cash. To explore this, I study the choice of payment method, specifically, between cash and electronic money. Each method offers distinct advantages and disadvantages.

One of the most important advantages of the cash is its high acceptability by sellers, making it a primary motivation for its use (Minsait Payments, 2022). This high acceptability is related to the fact that cash is the most liquid asset that exists, that is, through it people can immediately and directly obtain goods and services. Also, there is a permissionless access to use it. In other words, people do not face any access costs or prerequisites to participate (Berentsen and Schar, 2018). Another important reason is the anonymity it provides, as there are no records that enable tracking. About the disadvantages of cash, its anonymity can facilitate illegal activities, known as shadow economy, such as tax evasion, smuggling, drug trafficking, money laundering, and so on. Moreover, carrying cash in your pockets exposes you to the risk of robbery. Berentsen and Schar (2018) highlight that cash implies physical presence at the transaction location, which involves time and wear costs, often referred to as shoe-leather costs. Finally, although cash has no access costs, sellers and banks incur in additional operational costs or cost of handling cash. That is, cash needs to be "counted, bundled, transported, cleaned, replaced, checked for forgery, stored and guarded" (The Economist, 2016a).

In contrast, digital or electronic payment methods can include some benefits related to security, lower operating costs, convenience and social welfare. Electronic money restricts anonymity, thus, reducing illegal activities within the shadow economy, which increases social welfare. Also, it can mitigate fraud and theft in face-to-face transactions, although it might heighten the risk of cyber theft. Commercial transactions can occur with buyers and sellers physically distant from each other (Berentsen and Schar, 2018). In addition, electronic money can reduce the operational costs linked to cash, as previously mentioned, which enhances transaction efficiency and convenience. For instance, electronic cash in Japan "takes no more than a tenth of a second to complete most transactions. As no change is required, counting errors are eliminated" (The Economist, 2007b). However, electronic payment methods come with access costs for both sellers and consumers. To accept them, businesses need to invest in equipment, establish contracts with banks, and often pay monthly fees. Likewise, consumers typically require a debit or credit card, which involves a bank account, or a smartphone or computer with internet access to make transfers. In particular, people argue they do not have enough money to access digital methods, because financial services are either too costly or too geographically distant from their place of residence (World Bank, 2021). Regarding acceptability, in developing economies, digital payments are not widely accepted (World Bank, 2021). Specifically, in Latin America, not all merchants accept digital payments, just an estimated 26% of businesses accept electronic card payments through POS devices (Kushki and Payments and Commerce Market Intelligence, 2023). Therefore, electronic payment methods face limited acceptance among sellers.

A novel difference between cash and electronic payments lies in concerns regarding hygiene and public health. Various studies have demonstrated that paper money and coins can serve as vectors for viruses, germs, or bacteria, which can cause infections or diseases. The longer money -specifically, low denomination bills- circulates and the more frequently it changes hands, the greater the likelihood of becoming contaminated (Larson, 2021; Maron, 2017). Indeed, during the Covid-19 pandemic, there was a concern that infected banknotes would spread the virus.² Thus, many businesses encouraged consumers to use non-cash payment methods. Central banks in countries such as China, Korea, and USA opted to disinfect and quarantine banknotes before reintroducing them into circulation (The Economist, 2020).

I focus on the choice of payment method, considering three key attributes: acceptability, access costs, and disutility costs related to infection via viruses. The objective is to develop a theoretical model, based on the money search theory according to the New Monetarist approach (Lagos, Rocheteau, and Wright, 2017). The central question I aim to address is: Under what circumstances might cash, with its advantages in acceptability and access costs but drawbacks in disutility costs associated with the probability of infection, be preferred over electronic money, within an environment where both payment methods are in circulation? This model tackles the main research question by enabling agents to endogenously choose the optimal payment method based on the benefits and drawbacks associated with each option. The model studies the coexistence of cash and electronic money, as payment methods, within a tractable monetary framework. As there is absence

² Nonetheless, numerous studies demonstrated that the risk of contracting Covid-19 through the use of cash is very low (Deutsche Bundesbank, 2020; The Cash Management Companies Association, 2020).



of double coincidence of needs, no commitment, and no trading history record, the use of a means of payment becomes essential to achieve greater allocations.

Moreover, my model includes heterogeneity on consumer preferences and seller sizes. On the one hand, evidence indicates variations in digital payment usage among account owners with different income levels.³ Also there are disparities in the adoption of digital payments between account holders in the poorest 40% of households and those in the wealthiest 60% (World Bank, 2021). On the other hand, small merchants often perceive POS systems for digital payment acceptance as expensive and intricate; it involves contracting with a bank, incurring monthly fees, managing a physical device, among other complexities (Kushki and Payments and Commerce Market Intelligence, 2023).

The model finds that despite a highly enough probability of infection and resulting disutility when using cash, buyers may not necessarily abandon cash in favor of electronic money. Each buyer's choice of payment method depends on their capability to afford the access cost required for transitioning to electronic money. Similarly, the access cost threshold for using e-money is influenced, in equilibrium, by its acceptability. If the acceptability increases, certain buyers may switch to e-money by paying the access cost, while others may end up using only cash. Hence, cash can linger among various buyer types, according to the monetary equilibrium. From a different angle, the seller's decision to invest in technology to accept electronic money is considered endogenous. The result depends on the investment cost faced by each type of seller. That is, not all sellers might be able to cover the investment cost required to accept electronic money. This leads to a mixed monetary equilibrium characterized by two regimes. In the first, cash persists as the exclusive payment method accepted by small-sized sellers, while in the second, it remains prevalent among small and medium-sized sellers.

The remainder of the paper is organized as follows. Section 2 describes the related literature. In Section 3, I define the environment of the model. Section 4 examines the problem from the buyer's perspective, delving into aspects such as acceptability, preference shock, and disutility costs. An extension analyzes the seller's decision process, taking into account endogenous acceptability and the presence of heterogeneous sellers. Finally, in Section 5, I present some conclusions and policy recommendations.

2 Related literature

The relevant literature related to this research can be categorized into two main areas: the analysis of payment method choices using search money theory, and empirical studies examining the adoption of electronic payments.

Theoretically, search money models have delved into the choice of different types of money or competition between payment methods since the advent of first (Kiyotaki and Wright, 1991) and second-generation models (Shi, 1995; Trejos and Wright, 1995). Based on the second generation model, there are some papers: Kim and Lee (2010) analyze cash and debit cards; Liu and Shi (2010) present a model involving two countries, each with its own currency; Lotz (2004) focuses on an economy with two currencies; Burdett, Trejos

³ Other individual attributes that might influence the decision to own a bank account encompass factors such as gender, age, educational level, employment status, and residential location, whether in urban or rural areas (World Bank, 2021).

and Wright (2001) study the use of cigarettes as commodity money; and Shi (1996) explores the coexistence of money and credit.

Since the third generation model (Lagos and Wright, 2005), there have been many authors that have studied the choice of payment method between different types of money. A strand of the literature has explored various forms of electronic or digital money. Specifically, Chiu et al. (2023), Davoodalhosseini (2022), Keister and Sanches (2023), and Kwon, Lee, and Park (2022) develop a model allowing agents to hold both cash and Central Bank Digital Currency (CBDC), aiming to analyze the effects on intermediary banks, tax evasion or welfare. Additionally, Yu (2023) analyzes cryptocurrency and its interaction with fiat money circulation. Furthermore, Bajaj and Damodaran (2022), Vasselin (2020), Lotz and Vasselin (2019), Zhu and Hendry (2019), and Monnet and Roberds (2007) investigate the competition among cash with mobile money, privately issued e-money, card payments, or e-money in general. This paper closely relates to Bajaj and Damodaran (2022) and Lotz and Vasselin (2019) by incorporating preference shocks and the coexistence between cash and e-money.

Several authors have examined various types of financial assets, particularly focusing on money and credit. Dong and Huangfu (2021), Wang, Wright, and Liu (2020), Boel and Waller (2020), Jiang and Shao (2020), Rocheteau and Nosal (2017, chap. 8), Gu, Mattesini, and Wright (2016), Telyukova and Wright (2008), and Berentsen, Camera, and Waller (2007) explore the role of money and credit as means of payment. The use of these financial instruments depends on factors such as the cost of credit, inflation rates, or imposed debt limits. Additional authors, such as Lotz and Zhang (2016) and Sanches and Williamson (2010), delve into the study of money and credit, incorporating attributes like record-keeping technology to accept credit, limited commitment, imperfect memory, and issues related to theft. Finally, an essential function of financial intermediation in the economy is the reallocation of liquidity through credit. In this context, Frasser and Pájaro (2023) examine the role of liquidity reallocation via credit in mitigating the welfare cost of inflation, presenting the theoretical model and an application to the Colombian economy. Nevertheless, the present paper lacks a model that incorporates the use of credit, access to banks, or financial intermediation.

Various other financial assets encompass bonds, checking deposits, equity, and others. In this context, van Buggenum (2023) investigates the coexistence of money and bonds. Additionally, Rocheteau and Nosal (2017, chap. 12) explore the relationship between money and nominal government bonds, particularly these do not pay interest. Li (2011) incorporates checking deposits and cash into the analysis, with a focus on explicitly modeling asset liquidity. Lagos (2011) develops a model featuring money and equity shares, examining the effects of optimal monetary policies. Furthermore, He, Huang, and Wright (2008) introduce the possibility of money theft, prompting agents to deposit their cash into bank accounts, thereby allowing them to use either cash or bank liabilities. Lastly, Altermatt, Iwasaki, and Wright (2023) analyze multiple liquid assets including fiat currency, fixed-supply real assets, and reproducible capital, investigating the role of monetary policy. Lester, Postelwaite, and Wright (2012) delve into the rationale behind asset usage in transactions, considering assets such as equity and fiat currency, two commodities monies, and two fiat monies. Geromichalos, Licari, and Suárez (2007) study the relationship between real asset prices and monetary policy.

Finally, certain authors have studied other forms of money. For example, Frasser and



Lebeau (2023) examine the coexistence of fiat money and a coca-based complementary currency. In a different context, Choi and Rocheteau (2022) investigate two economies featuring distinct forms of money; the first includes two interest-bearing monies, while the second incorporates two fiat monies. Additionally, there exist papers addressing the intersection of money and capital (Rocheteau and Nosal, 2017, chap. 11; Aruoba, Waller and Wright, 2011; Lagos and Rocheteau, 2008), as well as the dynamics of international currencies in an open-economy setting (Gomis-Porqueras, Kam and Waller, 2017; Zhang, 2014; Kannan, 2009). My research does not include commodity money, capital, or an open economy framework.

About empirical studies, Srouji and Torre (2022) assess the pandemic's influence on payment systems and its implications for regulators and banks. Their findings suggest that while the pandemic enhanced the digital payment ecosystem, it also exacerbated fragmentation across different payment systems. Srouji (2020) explores the persistent use of cash in Gulf Cooperation Council countries and assesses whether the adoption of digital payments, as seen in South Korea and Sweden, is appropriate for these regions. The findings argue that transitioning to digital payments and reducing cash usage may not be suitable for countries characterized by high levels of socio-economic inequality. Arifovic, Duffy and Jiang (2017) develop a framework within a controlled laboratory environment, based on Kiyotaki and Wright (1991), to introduce a new payment method featuring fixed costs. Their findings indicate that a low fixed cost significantly accelerated the adoption of the new payment method among all participants.

3 Environment

The environment is based on the Lagos-Wright model (Lagos and Wright, 2005). It has been further developed to consider the coexistence of electronic money and cash by Lotz and Vasselin (2019), and to incorporate preference heterogeneity by Bajaj and Damodaran (2022).

There is a continuum $[0, 2]$ of agents, who live infinitely and are evenly divided into buyers and sellers. Time is discrete, and agents visit two distinct markets during each period that correspond to two subperiods: day and night. In the day, first subperiod, agents operate anonymously and participate in a *decentralized market* (DM) through a bilateral matching process. In this market, there is a division of labor where buyers are specialized in consumption and do not have the ability to produce, while sellers are specialized in production and do not consume the products they sell. Due to this specialization, there is a lack of double-coincidence of wants in the market, which means that bartering between buyers and sellers is not possible. Moreover, agents face several challenges that make cooperation difficult. These include the inability to commit to future transactions, and imperfect record-keeping devices, which exclude the use of credit. Without barter or credit, and with goods that cannot be stored, the use of money as a medium of exchange becomes crucial for facilitating trade.

At the beginning of DM, a buyer meets a seller, or vice versa, with probability $\sigma < 1$. When an agreement is reached, agents exchange a specified quantity of the DM good, called *search good*, in return for a corresponding amount of money. In this economy, there

are two types of money: agents can hold cash (also known as fiat money) or electronic money (often referred to as e-money). In the DM, goods can be exchanged for cash (f), e-money (e), or a combination of both, depending on the agent's portfolio. Both of these payment methods are easily divisible and storable, and their opportunity cost, as measured by the interest rate (i), is the same.

However, these payment methods differ due to three additional frictions. First, there is a perceived risk of virus infection, resulting from the use of the payment method. The agent faces a probability α of getting infected and incurring a positive disutility cost when using cash, and a probability μ of getting such infection and experiencing the disutility cost when using electronic money, where $\alpha > \mu > 0$. In contrast, the agent remains uninfected and the disutility cost will be zero, with probability $(1 - \alpha)$ by using cash, and $(1 - \mu)$ by using e-money.

Second, whereas cash is universally accepted by all sellers, electronic money exhibits partial acceptability. That is, there is a fraction $\Lambda < 1$ of sellers who accept both payment methods. This implies that a scenario in which all sellers universally accept electronic money is not possible. This aligns with the reality in many countries where the acceptance of electronic or digital payment methods remains limited. The remaining proportion of sellers, $(1 - \Lambda)$, only accepts cash. Third, besides the disutility costs, there is an access cost $\kappa > 0$ for using electronic money, similar to bank fees, which is borne by the buyers. Conversely, cash does not entail any access cost.

At night, the second subperiod, agents trade in a frictionless centralized market, called *competitive market* (CM). In the CM, all agents can produce or consume the *general good*, but they adjust their monetary balances through different actions: buyers produce to increase their money holdings, while sellers consume to reduce them. Furthermore, buyers choose which type of money to include in their portfolio for the following day. To simplify the notation, it is assumed that the infection and the disutility cost only occur in the DM, where buyers meet sellers bilaterally.

The preferences of the agents are given by $\sum_t \beta^t U_b^j(q^j, x^j, y^j)$ and $\sum_t \beta^t U_s(q^j, x^j, y^j)$, where $U^b(q^j, x^j, y^j)$ is the buyer- j utility function, $U^s(q^j, x^j, y^j)$ is the seller utility function, $q \in \mathbb{R}_+$ is the quantity of the search good traded in the DM, $x \in \mathbb{R}_+$ is the quantity of the general good consumed in the CM, and $y \in \mathbb{R}_+$ is the agent's disutility of labor in the CM. Notice that buyers exhibit heterogeneity among themselves based on the utility they derive from consumption of the search good, which arises from preference shock ε^j . Type- j buyer's utility is denoted by $\varepsilon^j u(q^j) > 0$ where $j \in \mathbb{I}$. The proportion of type- j buyer is denoted by π^j . When the terms of trade are established, the seller will produce the quantity of the search good q for the buyer- j . Furthermore, $c(q^j)$ the seller's cost for producing in the DM. Agents discount the future between each period at rate, $r = \beta^{-1} - 1$ where $\beta \in (0, 1)$ is the discount factor. It is assumed that utility functions of buyers U_b^j and sellers U_s are separable across subperiods:

$$U_b^j(q^j, x^j, y^j) = \varepsilon^j u(q^j) + x^j - y^j \quad (1)$$

$$U_s(q^j, x^j, y^j) = -c(q^j) + x^j - y^j \quad (2)$$

In both subperiods, the production technologies are linear in labor, and in the CM the utility function is linear in the hours of work. The utility and cost functions respect



the following properties: $u'(q^j) > 0$, $u''(q^j) < 0$, $u(0) = c(0) = c'(0) = 0$, $u'(0) = \pm\infty$, $c'(q^j) > 0$, $c''(q^j) > 0$, $c(\bar{q}^j) = u(\bar{q}^j)$ for some $\bar{q}^j > 0$. Let q^{j*} denote the optimal quantity produced and exchanged that maximizes the match surplus between a buyer and seller: $u'(q^{j*}) = c'(q^{j*})$.

At the beginning of DM, each buyer- j enters with f nominal units of cash and/or e nominal units of e-money, with $f \geq 0$ and $e \geq 0$, that is, their portfolio is: $m = f + e$. Nominal units of money are valued at $\phi_t = 1/p_t$ where ϕ_t is the price of money in terms of the *general good*. The real value of the nominal portfolio m is: $z = z_f + z_e$, where $z_f = \phi f$ and $z_e = \phi e$. The nominal aggregate stock of money is M_t , which includes cash and e-money, and the monetary authority can increase or decrease it at a constant gross rate: $\gamma = M_{t+1}/M_t$. Cash is injected ($\gamma > 1$) or withdrawn from the economy ($\gamma < 1$) through lump-sum transfers T to the buyers at night. At the beginning of CM, agents who possess e-money can exchange it for cash at zero cost, or reversely, with the corresponding e-money issuing institution. These institutions do not have a role in the secondary creation of money. In stationary equilibrium, the real value of the money supply remains constant over time: $\phi_t M_t = \phi_{t+1} M_{t+1}$. That is, the gross rate of return on money: $\phi_{t+1}/\phi_t = M_t/M_{t+1} = \gamma^{-1}$.

The timing of events and the preferences of agents are described in Figure 1.

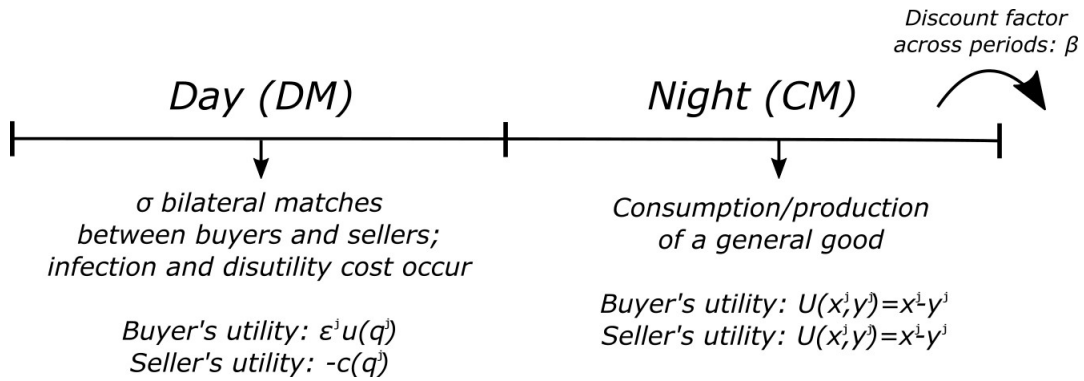


Figure 1: Timing of events and preferences.

4 Acceptability, preference shock, and disutility costs

In this section, I develop the value functions, the DM bargaining, optimal portfolio choice problem, and equilibrium. This occurs within an environment where various types of buyers- j interact, each one faces an access cost if they opt to use electronic money.

4.1 Value functions

The value function for a type- j buyer holding m^j units of money who enters the CM is, where V_{t+1}^b is the value function in the next subperiod:

$$W_t^b(z_f^j, z_e^j) = \max_{x^j, y^j, z_f^{j+}, z_e^{j+} \geq 0} \{x^j - y^j + \beta V_{t+1}^b(z_f^{j+}, z_e^{j+})\} \quad (3)$$

$$s.t. \quad x^j + \phi_t(f^{j+} + e^{j+}) = y^j + w + T \quad (4)$$

$$\phi_{t+1}(f^{j+} + e^{j+}) = z_f^{j+} + z_e^{j+} \quad (5)$$

The equation (4) represents the buyer's budget constraint: a buyer- j finances the costs of their money balances for the following day ($f^{j+} + e^{j+}$) and general good consumption (x) through a combination of labor (y), their current wealth (w), and their received transfers (T). The second constraint (5) describes the real value that the units of money will have in the following DM.

After rearranging:

$$W_t^b(z_f^j, z_e^j) = w + T + \max_{z_f^{j+}, z_e^{j+} \geq 0} \{-\gamma(z_f^{j+} + z_e^{j+}) + \beta V_{t+1}^b(z_f^{j+}, z_e^{j+})\} \quad (6)$$

The type- j buyer's lifetime expected utility is determined by the following factors: their current wealth, any transfers received, their value function for the next DM, and the cost of holding real balances (γ).

The buyer- j 's value function at the beginning of the DM is given by:

$$V_t^b(z_f^j, z_e^j) = -\alpha z_f^j - \mu z_e^j - \kappa \mathbb{1}_{z_e^j > 0} + \sigma \left[(1 - \Lambda) \left[\epsilon^j u(q(z_f^j)) + W_t^b(z_t^j - d_f(z_f^j), z_e^j) \right] + \Lambda \left[\epsilon^j u(q(z_f^j, z_e^j)) + W_t^b(z_f^j - d_f(z_f^j), z_e^j - d_e(z_e^j)) \right] \right] + (1 - \sigma) W_t^b(z_f^j, z_e^j) \quad (7)$$

A buyer- j may choose to hold cash (z_f) and/or e-money (z_e), but in doing so, they will experience the probability of getting infected and suffering a positive disutility cost using cash (α) and/or e-money (μ) in the DM. Moreover, if they decide to use e-money, they must pay the access cost (κ). When a buyer encounters a seller, with probability σ , who only accepts cash with probability $(1 - \Lambda)$, the buyer- j will exchange their cash (d_f) for the desired goods (q^j). Conversely, if the buyer- j meets a seller, with probability σ , who accepts both methods with probability Λ , they will exchange their e-money (d_e) and/or cash (d_f) for the goods (q^j). Notice that, regardless of the payment method used, whether cash or e-money, the type of product q^j remains the same. That is, there is no heterogeneity in the products being exchanged. If the buyer- j is unable to find a seller with probability $(1 - \sigma)$, they will simply maintain their current money balances.



4.2 DM bargaining

Once a buyer- j and seller have reached an agreement, the terms of trade (q^j, d^j) are established through pricing mechanisms, with $q^j \geq 0$ units of the search good, and $d^j \in \mathbb{R}_+$ representing the amount of money exchanged between the agents. The proportional solution, which was proposed by Kalai (1977), mandates that in bilateral trade negotiations, the buyer receives a constant fraction of the matching surplus, denoted by θ . In general terms, the maximization program is:

$$q^j = \arg \max_{q^j} \theta [\varepsilon^j u(q^j) - c(q^j)] \quad (8)$$

$$s.t. \quad \varepsilon^j u(q^j) - (z_f^j + z_e^j) \leq \theta [\varepsilon^j u(q^j) - c(q^j)] \quad (9)$$

$$d_f^j \leq z_f^j, d_e^j \leq z_e^j \quad (10)$$

If the equation (9) is binding:

$$z^j = z_f^j + z_e^j = d_f^j + d_e^j = (1 - \theta) \varepsilon^j u(q^j) + \theta c(q^j) \equiv p(q^j) \quad (11)$$

where $p(q^j)$ is a payment function. The quantity q_m^j traded in the DM, when buyers only hold one or another method of payment, is then given by:

$$q_m(z_m^j) = \begin{cases} q^* & \text{if } z_m^j \geq p(q^*) \\ p^{-1}(z_m^j) & \text{otherwise.} \end{cases} \quad (12)$$

where $m = f, e$. Hence, the buyer- j 's surplus is defined as:

$$S_m^b(z_m^j) = \begin{cases} \theta [\varepsilon^j u(q^*) - c(q^*)] & \text{if } z_m^j \geq p(q^*) \\ \varepsilon^j u(p^{-1}(z_m^j)) - z_m^j & \text{otherwise.} \end{cases} \quad (13)$$

4.3 Optimal portfolio choice problem

From the linearity of W^b , the equation (7) can be written as:

$$V_t^b(z_f^j, z_e^j) = -\alpha z_f^j - \mu z_e^j - \kappa \mathbb{1}_{z_e^j > 0} + \sigma \left[(1 - \Lambda) [\varepsilon^j u(q(z_f^j)) - d_f(z_f^j)] + \Lambda [\varepsilon^j u(q(z_f^j, z_e^j)) - (d_f(z_f^j) + d_e(z_e^j))] \right] + W_t^b(0, 0) + z_f^j + z_e^j \quad (14)$$

Due to inflation, always buyers- j will only hold onto the amount of money needed for trade, such that $d^j = z^j$. Then, equation (14) can be written as, using the buyer- j 's surplus (equation 13):

$$V_t^b(z_f^j, z_e^j) = -\alpha z_f^j - \mu z_e^j - \kappa \mathbb{1}_{z_e^j > 0} + \sigma [(1 - \Lambda) S^b(z_f^j) + \Lambda S^b(z_f^j, z_e^j)] + W_t^b(0, 0) + z_f^j + z_e^j \quad (15)$$

Notice that if the equation (15) is substituted into (6), by assuming that a buyer- j only carries cash (the conditions for this result will be proved in equilibrium below), the optimal portfolio choice problem is:

$$\max_{z_f^j \geq 0} \left\{ -(i + \alpha)z_f^j + \sigma [S^b(z_f^j)] \right\} \quad (16)$$

And if the buyer- j only carries e-money:

$$\max_{z_e^j \geq 0} \left\{ -(i + \mu)z_e^j - \kappa + \sigma \Lambda [S^b(z_e^j)] \right\}, \quad (17)$$

where $i = \frac{\gamma - \beta}{\beta}$ is the interest rate, and the buyer- j 's surplus can be expressed as:

$$\begin{aligned} S^b(z_f^j) &= \varepsilon^j u(p^{-1}(z_f^j)) - z_f^j \\ S^b(z_e^j) &= \varepsilon^j u(p^{-1}(z_e^j)) - z_e^j \end{aligned}$$

By comparing these two optimal portfolios, the buyer- j 's decision on the payment method, whether to use cash or electronic money, is driven by which method yields the maximum value:

$$V_t = \max\{V_t^b(z_f^j), V_t^b(z_e^j)\} \quad (18)$$

Finally, the money market clearing implies that real money demand and money supply are equal:

$$\sum_{j \in \mathbb{I}} (\pi_f^j z_f^j + \pi_e^j z_e^j) = \theta_t M_t \quad (19)$$

where the parameter π_f defines the proportion of buyers- j using cash, and π_e denotes the proportion of buyers- j using electronic money.

4.4 Equilibrium

The rate of return of cash, which is obtained by the first-order condition from equation (16), can be expressed as follows:

$$\sigma S_f^{b'}(z_f^j) = (i + \alpha) \quad (20)$$

where,

$$S_f^{b'}(z_f^j) = \begin{cases} 0, & \text{if } z_f^j \geq p(q^*) \\ \frac{\varepsilon^j u'[p^{-1}(z_f^j)]}{p'[p^{-1}(z_f^j)]} - 1, & \text{otherwise} \end{cases} \quad (21)$$

The derivative with respect to z_f^j shows how the surplus increases when an additional unit of cash is used in a trade, while the units of e-money remain constant.



The rate of return of electronic money, from equation (17), is expressed as:

$$\Lambda \sigma S_f^{b'}(z_f^j) = (i + \mu) \quad (22)$$

where,

$$S_e^{b'}(z_e^j) = \begin{cases} 0, & \text{if } z^j \geq p(q^*) \\ \frac{\varepsilon^j u'[p^{-1}(z_e^j)]}{p'[p^{-1}(z_e^j)]} - 1, & \text{otherwise} \end{cases} \quad (23)$$

Unlike equation (20), equation (22) depends on the parameter $\Lambda < 1$. Thus, the marginal benefit of carrying additional real balances in cash is greater than the marginal benefit of carrying additional real balances in e-money. This is because an additional unit of cash will increase the buyer's surplus with probability $\Lambda < 1$, whereas an additional unit of e-money increases the surplus with probability. In this regard, determining the optimal portfolio choice is a nontrivial decision. On the one hand, cash offers the advantage of universal acceptance relative to the limited acceptability of e-money. On the other hand, the disutility cost associated with cash exceeds that of e-money, yet e-money has entry cost κ that does not show up in the equation of its rate of return.

Lemma 1. *If the probability of getting infected and incurring a disutility cost using cash is sufficiently high, $\alpha > \tilde{\alpha}$, then the rate of return of e-money will dominate that of cash. Considering that $\Lambda < 1$ so that $\alpha > \mu$.*

If both cash and e-money circulate in the economy, equations (20) and (22) must be equal to ensure that their respective rates of return are the same. Thus, a threshold for α is obtained:

$$\alpha = \tilde{\alpha} \equiv [(1 - \Lambda)i + \mu] \frac{1}{\Lambda} \quad (24)$$

Notice that if $\alpha \in [0, \tilde{\alpha})$, the rate of return of cash exceeds that of e-money. If $\alpha \in (\tilde{\alpha}, 1]$, the rate of return of e-money surpasses that of cash. When $\alpha = \tilde{\alpha}$, the rates of return are the same and the buyer- j could be indifferent between them. Using equation (24), one also verifies that for $\alpha > \mu$, then:

$$\Lambda < \bar{\Lambda} \equiv 1 \quad (25)$$

The partial effects of the acceptability of e-money (Λ), and the probability of becoming infected and suffering a disutility cost using e-money (μ) on the threshold $\tilde{\alpha}$ are:

$$\frac{\partial \tilde{\alpha}}{\partial \Lambda} = - \frac{(i + \mu)}{\Lambda^2} < 0, \frac{\partial \tilde{\alpha}}{\partial \mu} = \frac{1}{\Lambda} > 0.$$

As the proportion of sellers accepting e-money (Λ) rises, then $\tilde{\alpha}$ decreases, which increases the possibility that the rate of return of e-money dominates that of cash. Furthermore, there is a positive relation between $\tilde{\alpha}$ and μ . Thus, if the probability of getting infected and suffering the disutility cost using e-money (μ) decreases, $\tilde{\alpha}$ decreases, which reinforces the chances of e-money outperforming cash in terms of rates of return.

Lemma 2. *A type- j buyer will carry electronic money in their portfolio if $\kappa \geq \bar{\kappa}^j \geq 0$, which holds when the proportion of sellers accepting e-money reaches a minimum level $\underline{\Lambda} \leq \Lambda < \bar{\Lambda}$. Otherwise, the use of e-money will be incentivized if and only if the access*

cost κ is subsidized in the economy.

According to the equation (18), the type- j buyer will choose the payment method that generates a greater value function V_t^b . Given the disadvantage of e-money (access cost κ) compared to cash, there will be a threshold for κ in which the buyer- j is indifferent between them, which occurs if and only if: $V_t^b(z_f^j) = V_t^b(z_e^j)$.

To find the threshold, equations (16) and (17) are taken to be equal:

$$\kappa = \kappa^{-j} \equiv - \underbrace{[(i + \mu)z_e^j - (i + \alpha)z_f^j]}_{\text{buyer- } j\text{'s net costs}} + \sigma \underbrace{\left[\Lambda \left[\varepsilon^j u(q(z_e^j)) - z_e^j \right] - \left[\varepsilon^j u(q(z_f^j)) - z_f^j \right] \right]}_{\text{buyer- } j\text{'s net surplus}} \quad (26)$$

Where $\bar{\kappa}^j$ is determined by the net disutility costs of e-money relative to cash, the opportunity cost of demanding money (i), and the buyer's net surplus of using e-money relative to cash. When $\bar{\kappa} = \bar{\kappa}^j$, the buyer- j will be indifferent between carrying cash and e-money. If $\bar{\kappa} > \bar{\kappa}^j$, that is, $V_t^b(z_f^j) > V_t^b(z_e^j)$, the buyer- j carries only cash; if $\bar{\kappa} < \bar{\kappa}^j$, that is, $V_t^b(z_f^j) > V_t^b(z_e^j)$, the buyer- j prefers electronic money.

Regardless of whether the rates of return are the same or not, there must be a threshold $\underline{\Lambda}$ that guarantees that $\bar{\kappa}^j \geq 0$. To simplify the notation, $S^b(z_e^j) = \varepsilon^j u(q(z_e^j)) - z_e^j$ and $S^b(z_f^j) = \varepsilon^j u(q(z_f^j)) - z_f^j$. Thus,

$$\Lambda \geq \underline{\Lambda} \equiv \frac{S^b(z_f^j)}{S^b(z_e^j)} + \frac{(i + \alpha)z_f^j - (i + \mu)z_e^j}{\sigma S^b(z_e^j)}. \quad (27)$$

Based on the equations (25) and (27), it can be established that $\underline{\Lambda} \leq \Lambda < \bar{\Lambda}$, which holds if $\frac{\sigma[S^b(z_f^j) - S^b(z_e^j) - \alpha z_f^j + \mu z_e^j]}{z_f^j - z_e^j} < i < \frac{\sigma S^b(z_f^j) - \alpha z_f^j + \mu z_e^j}{z_f^j - z_e^j}$. This condition indicates that a mini-mum level of sellers accepting e-money ($\Lambda \geq \underline{\Lambda}$) must exist for a buyer- j to decide to pay the access cost κ associated with using e-money. Otherwise, if the level of acceptability of electronic money is very low ($\Lambda < \underline{\Lambda}$), the only way for encouraging its usage by buyers- j is to subsidize ($\bar{\kappa}^j < 0$) the access cost κ in the economy.

The partial effects of the acceptability of e-money (Λ), the preference shock (ε^j), the probability of becoming infected and suffering a disutility cost using e-money (μ) and using cash (α) on the threshold $\bar{\kappa}^j$ are:

$$\frac{\partial \bar{\kappa}^j}{\partial \mu} < 0, \frac{\partial \bar{\kappa}^j}{\partial \alpha} > 0, \frac{\partial \bar{\kappa}^j}{\partial \varepsilon^j} > 0, \frac{\partial \bar{\kappa}^j}{\partial \Lambda} > 0.$$



About the disutility costs, when μ increases, $\bar{\kappa}^j$ decreases, which means that if the probability of getting infected and incurring a disutility cost using e-money increases, the threshold $\bar{\kappa}^j$ for using electronic money decreases. In other words, buyers will be less likely to pay the access cost κ and use e-money. In contrast, if α increases, $\bar{\kappa}^j$ increases, which implies that if the probability of getting infected using cash increases, buyers are more inclined to cover the access cost κ . Analogously, when Λ increases, $\bar{\kappa}^j$ increases, the likelihood that buyers pay the access cost κ rises.

Now it can be assumed, without loss of generality, that there are three types of buyers: lower class (l), middle class (m), and high class (h); with preferences given by $\varepsilon^h > \varepsilon^m > \varepsilon^l$ and proportions $\pi^l + \pi^m + \pi^h = 1$. The parameter $\pi_f \in [0,1]$ defines the proportion of buyers using cash, while the remaining proportion, denoted by π_e , are buyers using electronic money. Hence, the aggregate proportion of buyers- j is $\pi_f^j + \pi_e^j = 1$. Notice that $\bar{\kappa}^j$ is increasing in ε^j . Thus, if there is the case that a type- l buyer prefers e-money, then a type- m buyer will also prefer e-money: as $\varepsilon^m > \varepsilon^l$, then $\kappa < \bar{\kappa}^l < \bar{\kappa}^m$. Similarly, if there are type- h buyers ($\varepsilon^h > \varepsilon^m > \varepsilon^l$), they also will prefer e-money because $\kappa < \bar{\kappa}^l < \bar{\kappa}^m < \bar{\kappa}^h$. In simple terms, if a lower-class buyer can afford the access cost κ for using e-money, then a higher-class buyer can also afford it.

Equilibrium definition 1. A steady-state monetary equilibrium is defined as follows:

1. A *pure cash equilibrium* with $\pi_f = 1$ and $\pi_e = 0$ consists in a list (q_f^j, ϕ, z_f^j) jointly satisfying equations (12), (19), and (20).
2. A *pure e-money equilibrium* with $\pi_e = 1$ and $\pi_f = 0$ consists in a list (q_e^j, ϕ, z_e^j) jointly satisfying equations (12), (19), and (22).
3. A *mixed monetary equilibrium* with $\pi_f > 0$, $\pi_e > 0$ and $\pi_f + \pi_e = 1$ consists in a list $(q_f^j, q_e^j, z_f^j, z_e^j, \phi)$. For buyers holding only cash, (q_f^j, z_f^j) solve equations (12) and (20), while that for buyers holding only e-money (q_e^j, z_e^j) , solve (12) and (22). The value of ϕ is derived from (19).

Proposition 1 (Monetary equilibria). There is a unique steady-state monetary equilibrium for each of the following regimes:

1. If $\alpha < \tilde{\alpha}$, and for $\kappa \geq 0$, then a *pure cash equilibrium* exists with $\pi_f = 1$,
2. If $\alpha > \tilde{\alpha}$, and
 - (a) $\kappa \geq \bar{\kappa}^h$, then a *pure cash equilibrium* exists with $\pi_f = 1$,
 - (b) $\bar{\kappa}^m \leq \kappa < \bar{\kappa}^h$, then a *mixed monetary equilibrium* exists with $\pi_f = \pi^m + \pi^l$,
 - (c) $\bar{\kappa}^l \leq \kappa < \bar{\kappa}^m$, then a *mixed monetary equilibrium* exists with $\pi_f = \pi^l$,
 - (d) $\kappa \geq \bar{\kappa}^l$, then a *pure e-money equilibrium* exists with $\pi_e = 1$.

The first regime shows that when the probability of getting infected and incurring a disutility cost using cash is sufficiently low ($\alpha < \tilde{\alpha}$) joint with a positive access cost for using e-money, all buyers- j use cash. If α decreases, the rate of return of cash is higher than the rate of e-money, from Lemma 1; and $\bar{\kappa}^j$ decreases. This leads buyers to choose only cash. They benefit from its high acceptability, zero access costs, and the lower probability of getting infected with a virus.

Notice that, in the second regime, when the probability of getting infected and incurring a disutility cost using cash increases high enough ($\alpha > \tilde{\alpha}$), it does not automatically mean that the buyer stops using cash. There are two effects. First, the rate of return of e-money dominates that of cash, from Lemma 1. Consequently, the real balances of cash (z_f) reduce, resulting in reduced consumption among buyers using cash, from (20). This would tend to decrease the preference for cash among buyers, while an increase in electronic money usage. However, the second effect refers to the buyers' ability to afford the access cost to switch to e-money, which determines their choice of payment method.

As an example, imagine that α increases, the threshold cost $\bar{\kappa}^j$ for using e-money will also increase, for all type- j buyers. If the increase in $\bar{\kappa}^j$ is enough that high-class buyers (ε^h) switch from cash to e-money by paying the access cost κ , then their money real balances (z_e) and consumption will increase, from Lemma 1. But if the increase in $\bar{\kappa}^j$ is not high enough for lower-class (ε^l) and middle-class (ε^m) buyers switch to e-money, then they must continue using cash, and consumption decreases, as $\bar{\kappa}^l < \bar{\kappa}^m \leq \kappa < \bar{\kappa}^h$.

Hence, only a significant rise in the probability of getting infected and incurring a disutility cost using cash (α), aligning with a considerable increase in the threshold of the access cost ($\bar{\kappa}^j$), could potentially lead to a cashless economy. For instance, during the COVID-19 pandemic, the perception of infection risk associated with using cash diminished rapidly, influenced by various studies⁴, central bank statements⁵, and the progress in vaccine development. Thus, diverse buyers maintained their trust in and continued using cash.

Consequently, a proportion of buyers may still prefer cash as their payment method of choice. In this particular case, the economy will be in a *mixed monetary equilibrium*, with cash being chosen by lower-class and middle-class buyers, while high-class buyers will access and use electronic money. Note that a heterogeneity effect exists. When the perception of infection risk by using cash reaches a certain threshold, the initial buyers who transition to electronic money are mainly buyers from higher classes. Evidence shows that, in developing countries, 83% of the richest account owners utilize digital payments, compared to 74% of poorest account owners, representing a gap of 9 percentage points (World Bank, 2021). Moreover, since the 1970s, credit cards were introduced as electronic payment methods and swiftly gained popularity among the middle-high and high-class people (Kushki and Payments and Commerce Market Intelligence, 2023).

The previous mechanisms work the same with the proportion of sellers accepting both payment methods, as $\bar{\kappa}^j$ depends positively on Λ . Notice that an increase in Λ causes an increase in consumption of buyers who use e-money, from (22). Consider that $\bar{\kappa}^j$ increases in response to an increase in Λ . As mentioned above, the rise significant enough in $\bar{\kappa}^j$ may allow high-class buyers to pay the access cost κ and to be able to switch to e-money and increase their consumption, but lower-class and middle-class buyers are unable to afford it and their consumption will remain constant. Hence, an increase in the proportion of sellers accepting both payment methods leads as well to a *mixed monetary equilibrium*,

⁴ Medical experts claimed that there is no evidence that the SARS-CoV-2 virus is spread via cash or euro banknotes (Cash Matters, 2020).

⁵ Deutsche Bundesbank eurosysteem asserted that the banknotes and coins do not have any risk of infection, and the probability of becoming ill from using cash is smaller than other objects (Deutsche Bundesbank, 2020). Even, in some countries, such as France, the authorities reminded sellers that the acceptance of cash is compulsory by law (CashEssentials, 2020).



where buyers from lower classes will use cash, contingent upon the magnitude of $\bar{\kappa}^j$. Observe, in this particular case, that even though the acceptability of electronic money by sellers may rise, lower-class and middle-class buyers do not reject the use of cash. The outcome still relies on the buyer's capacity to pay the access cost for using e-money. This theoretical insight accounts for the empirical data: globally, 36% of unbanked adults argue that financial services are too costly, while in Latin America and the Caribbean, this figure spikes to 60% among unbanked adults (World Bank, 2021).

From this perspective, two mechanisms can drive the adoption of electronic money: heightened risks of virus and bacteria transmission associated with cash usage, and the growing acceptance of electronic money by more sellers. However, not all buyers can switch to e-money due to their inability to cover the access cost. This highlights the lingering use of cash as a preferred payment method for a portion of buyers.

4.5 Extension: Optimal Seller Decision-Making

Up until now, notice that the decision to accept e-money by the sellers was exogenous. However, in this extension, the decision becomes endogenous. Now, I will delve into how this decision is made by the seller. Hence, a new friction is introduced in the environment. Sellers are required to invest in a technological device that enables them to accept electronic money as payment. That is, the seller incurs an investment cost $I > 0$.

Now, there is not a preference shock in consumption that generated heterogeneous buyers. Instead, consider that there is a shock ξ^k in the investment cost I , leading to heterogeneity among sellers in their capacity to pay the fee. Type- k seller's investment cost is denoted by $\xi^k I > 0$, where $\kappa \in \mathbb{I}$. The proportion of type- k sellers is denoted by ω^k , where sellers who exclusively accept cash are represented by ω_f , while sellers who accept both methods are denoted by $\omega_{f,e}$. Hence, the aggregate proportion of sellers- k is $\omega_f + \omega_{f,e} = 1$. Notice that, $\Lambda = \omega_{f,e}$ and $1 - \Lambda = \omega_f$.

The bargaining protocol in this extension is the same as the DM bargaining of the previous section. To encourage sellers to invest in the technology required for accepting e-money, the proportional bargaining solution should be employed. This allows sellers to extract a positive fraction of the total surplus.

In order to maximize the parameter Λ :

$$\sigma = \max_{\Lambda \in [0,1]} \{ \Lambda(-c(q) + (z_e + z_f) - \xi^k I) + (1 - \Lambda)(-c(q) + z_f) \} \quad (28)$$

By obtaining the F.O.C:

$$-c(q) + (z_e + z_f) - \xi^k I - (-c(q) + z_f) = 0 \quad (29)$$

When the seller accepts both payment methods, their trade surplus is $S^s(z_f, z_e) = -c(q) + z_e + z_f$, otherwise, it is $S^s(z_f) = -c(q) + z_f$.

Substituting these trade surpluses into (29):

$$S^s(z_f, z_e) - \xi^k I - S^s(z_f) = 0 \quad (30)$$

By substituting the terms of trade (equation 11) into (29) to obtain a threshold for I :

$$I = \bar{I}^k \equiv (1 - \theta) \left[u(q(z_f, z_e)) - c(q(z_f, z_e)) \right] - \left[u(q(z_f)) - c(q(z_f)) \right] \frac{1}{\xi^k} \quad (31)$$

Where the threshold $\bar{I}^k$ represents the point at which sellers are indifferent about investing in the technology to accept electronic money, as their surplus gained from accepting only cash equals their surplus from accepting both cash and e-money.

Lemma 3. A seller will decide to invest in technology to accept electronic money in the following cases, according to conditions (30) and (31):

$$\begin{cases} I > \bar{I}^k \Rightarrow S^s(z_f, z_e) - \xi^k I < S^s(z_f) \Rightarrow \Lambda = 0 \\ I < \bar{I}^k \Rightarrow S^s(z_f, z_e) - \xi^k I > S^s(z_f) \Rightarrow \Lambda = 1 \\ I = \bar{I}^k \Rightarrow S^s(z_f, z_e) - \xi^k I = S^s(z_f) \Rightarrow \Lambda \in (0, 1) \end{cases} \quad (32)$$

If $I > \bar{I}^k$ then $S^s(z_f, z_e) - \xi^k I < S^s(z_f)$, the seller's trade surplus is greater when they only accept cash compared to when they accept both methods. In other words, the surplus for sellers accepting electronic money may not be enough to justify investing in the technology. That is, the monetary balances of e-money that sellers will receive are less than the investment cost: $z_e < \xi^k I$.

If $I < \bar{I}^k$ then $S^s(z_f, z_e) - \xi^k I > S^s(z_f)$, the seller's trade surplus when they accept both payments methods is higher. There will be an incentive to invest in technology. This implies that the monetary balances of e-money that sellers will receive are greater than the investment cost, that is, $z_e > \xi^k I$.

When $S^s(z_f, z_e) - \xi^k I = S^s(z_f)$, which occurs when $I = \bar{I}^k$, sellers will be indifferent regarding the acceptance of payment methods because trade surpluses are equal. This means that the monetary balances of e-money that sellers will receive are equal than the investment cost: $z_e = \xi^k I$.

Notice that $\bar{I}^k$ is decreasing in ξ^k . This entails that if a small-sized seller with ξ^s can pay the investment cost ($I < \bar{I}^s$) for accepting e-money, then a medium-sized seller with $\xi^m < \xi^s$ also will pay it. Similarly, a large-sized seller with $\xi^l < \xi^m < \xi^s$ could cover the investment cost, as $I < \bar{I}^s < \bar{I}^m < \bar{I}^l$. In other words, if a small seller has the ability to afford the investment cost I , a larger seller will find it comparatively easier to pay it.



Equilibrium definition 2. A stationary equilibrium is a list (q, z_f, z_e, Λ) that satisfies the equations (11), (20), (22), and (32).

1. (*Pure cash equilibrium*). If $I > \bar{I}^k$, no type- k seller will have the capability to afford the investment cost since there will be no incentive. Therefore, the entire proportion of sellers only will accept cash:

$$q = q_f \leq q^*, \quad z_f = z(q), \quad z_e = 0, \quad \Lambda = 0, \quad \omega_f = 1$$

2. (*Pure e-money equilibrium*). If $I < \bar{I}^k$, type- k sellers have a greater incentive to invest in technology, increasing the likelihood that buyers will find a seller that accepts electronic money. Since $\alpha > \mu$, the only possible equilibrium is using e-money, and the entire proportion of sellers will accept e-money:

$$q = q_e \leq q^*, \quad z_f = 0, \quad z_e = z(q), \quad \Lambda = 1, \quad \omega_f = 0$$

3. (*Mixed monetary equilibrium*). If $I = \bar{I}^k$ sellers will be indifferent whether or not they invest in technology. If $\alpha = \tilde{\alpha}$, some type- k sellers will accept both methods, the remaining proportion will accept only cash:

$$q \leq q^*, \quad z = z(q), \quad \Lambda \in (0,1), \quad \omega_f \in (0,1)$$

Proposition 2 (*Mixed monetary equilibria*). There is a unique steady-state mixed monetary equilibrium for each of the following regimes:

1. If $\bar{I}^m < I \leq \bar{I}^l$, then a *mixed monetary equilibrium* exists with $\omega_f = \omega^s + \omega^m$,
2. If $\bar{I}^s < I \leq \bar{I}^m$, then a *mixed monetary equilibrium* exists with $\omega_f = \omega^s$.

In this extension, the type- k seller makes a decision when facing an investment cost I to accept e-money. The decision to invest in the technology for accepting e-money will depend on the threshold of investment costs faced by each seller. For instance, empirical evidence indicates that merchants argue that accepting digital payments is unattractive due to high fees or the unreliable physical infrastructure, such as network connectivity (World Bank, 2021). Thus, not all sellers will have the capability to finance the investment cost required to enable them to accept electronic money.

According to the Proposition 2, one regime involves large and medium-sized sellers being able to pay the technology to accept e-money, since the investment cost is attainable for them ($I < \bar{I}^m < \bar{I}^l$). But for small-sized sellers the investment cost can be unattainable ($I > \bar{I}^s$). In this case, the economy will converge to a *mixed monetary equilibrium*, where the proportion of medium and large sellers accepting both payment methods, while smaller sellers exclusively accept cash. This result reflects the real-world scenario where cash usage continues to be prominent among smaller sellers (Minsait Payments, 2022). It is justified by the cost barriers that face some sellers from investing in equipment, devices, or bank contracts required to accept electronic money (Kushki and Payments and Commerce Market Intelligence, 2023).

5 Conclusions and policy recommendations

To comprehend why, especially in developing economies, a sizeable segment of the population still relies on cash, I delved into the choice of payment method by buyers. This analysis focused on three key aspects: acceptability, access costs, and the disutility costs associated with infection from viruses or bacteria. Through a theoretical model, based on the New Monetarist approach (Lagos, Rocheteau, and Wright, 2017), I enabled buyers to endogenously choose the optimal payment method, considering the advantages and disadvantages inherent in each method.

The results, on the one hand, showed that even with increased risks of virus and bacteria transmission associated with cash and the increasing acceptance of e-money, buyers might not universally forsake cash for e-money. The choice of payment method depends on each buyer's ability to afford the access cost needed to shift to e-money, resulting in distinct monetary equilibria. In mixed monetary equilibria for buyers, cash is the preferred payment method for lower-class buyers, depending on the magnitude of the access cost threshold. Even cash could be preferred by higher-class buyers, leading to a pure cash equilibrium. On the other hand, when the seller's decision to invest in e-money technology becomes endogenous, sellers consider the level of investment costs they face to accept e-money. That is, not all sellers will be able to afford the investment cost required to accept it. In the mixed monetary equilibrium, cash remains the only accepted payment method, particularly among smaller-sized sellers or small and medium-sized sellers. Therefore, cash demonstrates a lingering use. Depending on the monetary equilibrium, lower-class buyers continue to rely on cash due to their inability to pay access costs to use e-money. Similarly, smaller-sized sellers exclusively accept cash as a payment method, given their constraints in investing the technology required for electronic money transactions.

The World Bank (2021) emphasizes that promoting financial inclusion is an important mechanism for the development of economies. One way to improve it is through digitalization, encouraging both demand (buyers) and facilitating supply (sellers). This involves boosting infrastructure, expanding networks, eliminating regulatory barriers, and reducing access costs. In other words, it is crucial to "enabling actors such as governments, telecommunications providers, and financial services providers must create an environment in which safe, affordable, and convenient products and functionality are more appealing than cash" (World Bank, 2021, p. 52). Thus, if the goal of policymakers is to promote digital and electronic payments, according to this paper, they should focus on reducing the level of access costs for buyers, particularly those from lower-class buyers. Similarly, they should work on lowering the investment costs for sellers, especially those operating as smaller-sized sellers. However, it is important to consider that transitioning to a cashless economy without simultaneously enhancing financial inclusion can cause some risks for vulnerable segments of the population. Groups such as poor, elderly or phoneless people, and those heavily reliant on cash, including churches, charitable organizations, and homeless individuals, may have considerable challenges during this transition (The Economist, 2016b). In times of economic turmoil, these groups may face a more significant decline in their well-being compared to middle or upper-class households who have greater protection within the financial system.



Finally, considering the limitations and future research directions, an empirical approach using calibration could measure the impact of a transition to a cashless society on the well-being of diverse buyer types. Additionally, enhancing the theoretical model by including extensions could enrich it and get closer to real-world scenarios. These might encompass exploring potential cyber risks associated with e-money, incorporating banks that allow e-money could generate interest but are subject to taxation, and studying the effect of monetary policy on electronic money.

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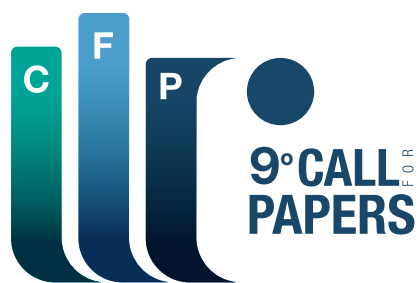
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